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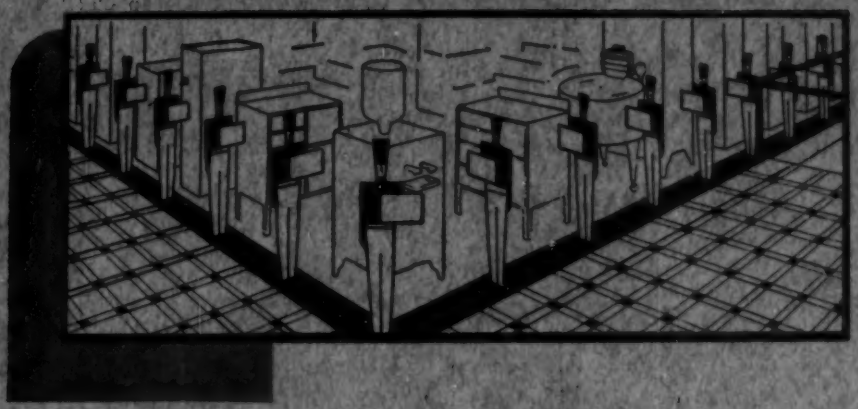

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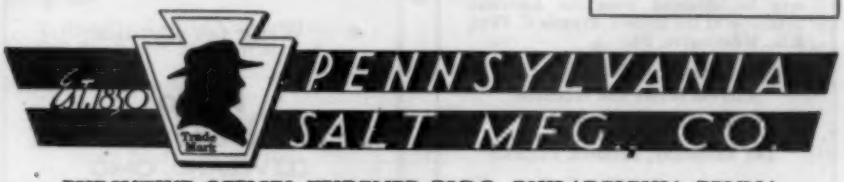

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DE-AIRING STIFF-MUD BODIES BY MEANS OTHER THAN THE VACUUM METHOD*

By H. R. Straight

ABSTRACT

A new design of auger blades and pug-mill knives which avoid working air into the clay mass during tempering and forming is presented.

I. Introduction

A few simple changes in the design of pug paddles and augers will overcome a considerable portion of the troubles traceable to air blebs, to well-distributed air, and to auger laminations.

In all clays the evacuation of air increases plasticity, moldability, and green and dried strength. It also allows more rapid drying[1] with less loss due to improved capillarity, increases dried and fired strength, and allows more thorough vitrification at lower temperatures with a resulting saving in fuel. Fuel will be saved, however, only where the material is low in carbon on account of the difficulty of oxidized air which penetrates an air-evacuated body.

(1) De-Airing Machine Used Since 1927

The writer designed and since 1927 has been operating a machine in which a major portion of the air was evacuated by using a vacuum pump and other suitable appurtenances. All of the expected advantages were gained, but there was considerable expense connected to designing and building the machine and operating the system, and while there was some additional power expended in operating the vacuum pump it was largely saved in the power required to operate the auger machine. The reason for the power saved is not yet fully determined, but it is thought to be due to decreased resiliency of the plastic clay.

During the past year experiments have been conducted which have given results practically the same as were accomplished by the vacuum pump. There are a few basic facts that have appeared in addition to those connected with the vacuum-pump system.

II. General Observations

(1) The longer or more times the clay is pugged the "shorter" it becomes, the more evenly the air entrapped becomes mixed throughout, and, sometimes in fatty clays, the more lamination it shows in the molded unit.

(2) If the pug knives are kept submerged less air will be worked into the plastic clay mass.

(3) Lamination is directly formed by the auger leaves, dividing the column of clay into streams or sections which are never properly united again.

(4) Pug-mill mixing is not dissimilar in principle to an egg beater; it works best when the backs of the blades are blunt. The reason for this condition may be because it carries more air in the mixture.

---

* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (Structural Clay Products Division).

[1] Editor's Note: More rapid drying has not been found in de-airing most close-grained clays. In fact, slowing down the drying time is the general tendency in many close-grained clays.

III. Streamline Auger Design

In the effort to accomplish better results two basic changes have been made which, at practically no added cost, are applicable to any stiff-mud clayworking machine with a resulting saving in the power required. These changes are as follows:

(1) The back sides of the pug blades are streamlined to prevent suction down the back of the blade, and the pitching back of the front edge of the pug blade gives a sliding or slicing cut.

(2) Streamlining each discharge end of the auger wings eliminates the suction of the square end which segregates air and lays it in a definite layer between the streams of clay.

These changes involve no extra equipment or radical changes in the present set-up and actually cut operating expenses of equipment now being used.

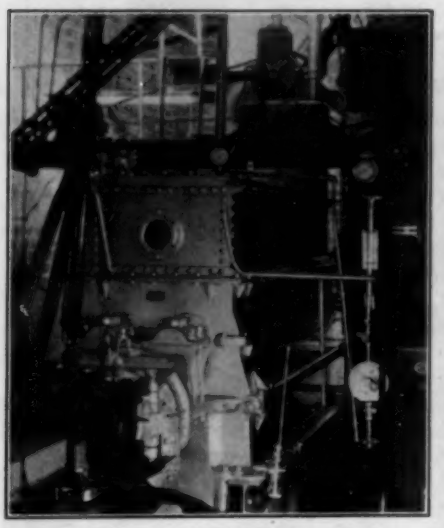

FIG. 1.—Auger machine showing vacuum pump above vacuum chamber.

(1) Less Power The new design of knife requires less power for two reasons. A slicing cut, as in meat cutters, requires less power because it rolls the cohering particles apart instead of wedging its way through. Streamlining saves power from an aero-dynamic standpoint, which in this case is quite small but important.

(2) Elimination of Trapped Air Clay can not close in immediately behind the blade on account of its inertia and plasticity and therefore something more fluid must fill the space displaced by the moving blade. The surrounding air is sucked in to fill the void. The blunt backs of the blades pump air into the mixtures. Obviously, to stop this suction it is necessary to extend the back of the blade. The amount of blade extension required depends on the stiffness of the clay, the speed of the shaft, and the angle at which the blades are pitched from a plane perpendicular to and cutting the center line of the shaft. For the best blade action the whole blade must maintain a slight polish to accomplish the streamlined action.

FIG. 2.—Various sizes of streamlined mill and pug-mill knives showing self-sharpening tip.

NOTE: Trouble is occasionally found from tramp iron in the auger machine. This frequently lodges between the end of the pug knife and the shell of the pug tub. The conventional type of pug knife sets up a toggle action which sometimes bends the pug shaft or punches a hole in the tub.

The new design is nontoggling because at no point in the accidental bending backward of the blade is there a position permitting a greater length of the blade to come between the shaft and the pug tub than the radial distance from the shaft outward to the end of the knife. Furthermore, any wedging action of the tramp iron tends only to free itself as the knife is sprung backward.

IV. Effect of Streamlining End of Auger Wings

The conventional design heretofore has been to run the auger wing or wings out the full thickness at the end with a square or very blunt end

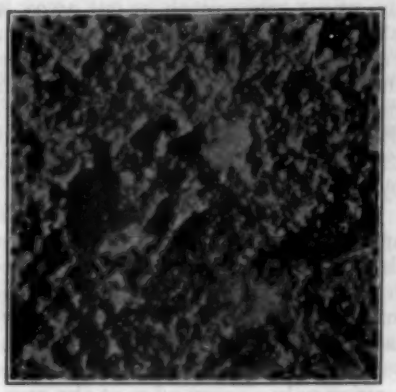

FIG. 3.—Body formed with blunt-end auger wing.

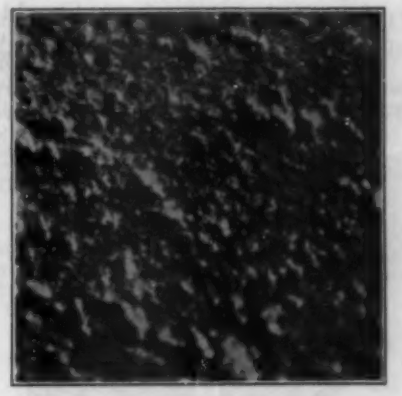

FIG. 4.—Same body as Fig. 3, with blunt-end auger with 22 inches of mercury vacuum.

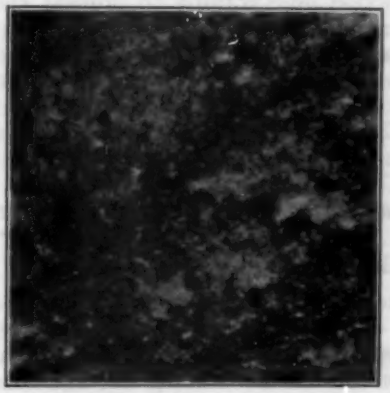

FIG. 5.—Body formed by improved pug blade and auger.

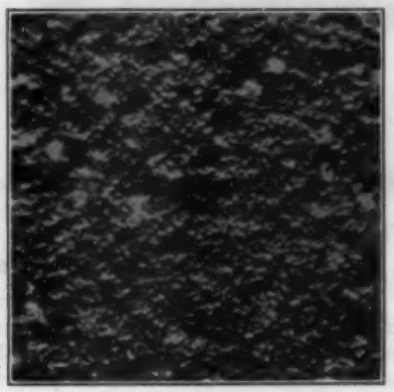

FIG. 6.—Body on which 22 inches of mercury vacuum have been used with a streamlined auger.

past which the clay is discharged as it leaves the auger. The clay will not expand instantaneously as it passes the end of the auger wing. The effect is to form a vacuum. In fact the blunt end past which the clay is discharged simulates the piston of a vacuum pump except that in this case

the shape is irregular instead of circular. The vacuum formed is relieved only by the flow of air out of the body of the clay.

The smoothed surfaces being air-lubricated form laminated conelike structures in the molded unit by the drag of the die. It is impossible for two particles of clay immediately opposite and on each side of this film of air to cohere, regardless of the pressure exerted. Streamlining the end of the auger wing is obviously a simple way to eliminate this segregation of the air in the body and to cause almost perfect adherence of the two or more streams of clay coming out from the auger.

(1) Correct Streamlining of the Auger Wing

Should the auger wing pitch be cut away in front to sharpen the discharge edge it is seen that there would be a portion of the auger which would exert little or no forward moving pressure on the clay column. The result would be increased weave in the column, different densities in the unit at different points, and all the other troubles which are caused by an unbalanced auger.

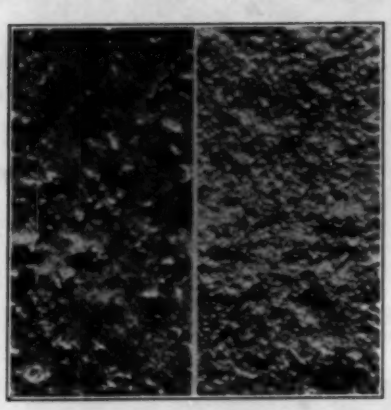

FIG. 7.—(*a*) (left) Die surface in which air has not been evacuated; (*b*) (right) Die surface in which air has been partially evacuated.

Another way to streamline the auger end is to increase the pitch on the back of the auger wing near the end of the wing without any change on the front side of the wing. The increase of the back pitch causes the surfaces finally to intersect in a line leaving only a sharp edge at the auger wing end with no cross-sectional area on blunt end to cause displacement. Therefore there is no surface to cause suction and nothing to prevent the emerging stream of clay from expanding and filling in entirely behind the stream of clay which has been previously expressed from the auger. The clay is all laid together in a smooth steady manner with no interruption to the pressure on any part of the back side of the die.

Photomicrographic studies of the clay surfaces produced are shown in Figs. 3 to 7.

V. Effect of De-Airing on Drying

It has been stated that air-evacuated ware needs more time for safe drying and consequently more drying equipment for a required tonnage, but the writer has not found this slower rate of drying. A high vertical rate of circulation is used, varying from 60 feet per minute average near the ware-discharge end to 25 feet per minute average at the ware-receiving end of the drier.

Drying of clayware is just the reverse of the action sought in dry farming. A dry mulch is finely divided soil with a high content of entrapped air. Internal diffusion of moisture is retarded by the entrapped air. Therefore, conversely, it should follow in open-bodied air-evacuated clay units that the diffusion of the moisture from the center of the unit to the surface should present a more flat capillary potential gradient.

NOTE: Tests have been made at the Massachusetts Institute of Technology to show that wood saturated with water containing air dries faster than the same wood saturated with de-aired water. It is apparent, therefore, why a close-grained fatty de-aired clay should dry more slowly since the air can not penetrate the body to displace the moisture in the voids, with the result that the moisture is securely held within the body and leaves the clay with difficulty.

It is believed that there is a critical point in grain size and body structure which can be reached in the de-airing of molded units of some clays beyond which drying will be difficult.

VI. Effect of De-Airing on Oxidation

Some clays present a real problem in the oxidation of carbon which must be oxidized before vitrification can be safely accomplished. Those manufacturers who have a highly carboniferous clay should carefully test the clays from this standpoint before purchasing vacuum equipment, although recent experiments at Iowa State College tend to show that no ordinary shales or fire clays in this particular section of Iowa will be at all troublesome from this standpoint.

Acknowledgments The writer wishes to acknowledge the assistance of William Jennings of Iowa State College in making the photomicrographs and also of Thomas K. Sherwood of the Massachusetts Institute of Technology for the valuable suggestions in connection with the drying of woods.

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THE EFFECT OF MECHANICAL PRESSURE ON THE IMBIBITIONAL AND DRYING PROPERTIES OF SOME CERAMIC CLAYS, II*

By A. E. R. Westman

ABSTRACT

The apparatus and technique used in a study of the permeable-pressing characteristics of ceramic clays, described in a previous paper with the same title, were used in making a detailed study of the effect of molding pressure on the properties of permeable-pressed disks of Florida and Delaware kaolins. The effect of initially high pressures on the properties of disks made at low pressures was investigated, and the rate of water removal was studied. The permeable-pressing characteristics of mixtures of clays and nonplastics were investigated at high and low pressures and the firing properties of permeable-pressed clay disks made in the previous investigation were determined. Further work with larger disks is in progress.

I. Introduction

(1) Purpose and Scope In a previous paper with the same title,[1] experiments were described in which a number of ceramic clays in the plastic condition were held between water-permeable pistons under mechanical pressures of 207, 8280, and 16,560 pounds per square inch in contact with water at atmospheric pressure until equilibrium was reached; the water in the pistons was removed by compressed air, the mechanical pressure released, and the moisture content, density, drying shrinkage, and other properties of the clays were determined. It was found that the effects of the shrinkage stage in drying were obtained at relatively low pressures approximating those required to overcome the capillary suction of the clays, that higher pressures gave higher dry densities than air drying, and that clays of the ball clay and china clay types were sharply differentiated at low pressures but not at high pressures.

The present paper describes further experiments using the same apparatus and technique in which two distinctive clays were pressed at a series of pressures, the effects of mixing clays and adding nonplastic ingredients were investigated, and a preliminary study was made of the firing properties of clays which had previously been subjected to mechanical pressure under the conditions described in the foregoing paper.

II. Relation between Properties of Clays Subjected to Permeable Pressing and Molding Pressure

(1) Florida Kaolin To show more clearly the relation between molding pressure and the properties of clays subjected to permeable pressing, disks of Florida and Delaware kaolins were made at a series of six pressures varying from 207 to 16,560 pounds per square inch. The Florida kaolin was chosen as a representative of clays of the ball clay type which required higher pressures to prevent drying shrinkage than those of the china clay type represented by Delaware kaolin. The plastic volumes in the press, the plastic volumes after the release of pressure, and the volumes of the disks of Florida kaolin after drying are shown in

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* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (White Wares Division).

[1] A. E. R. Westman, "The Effect of Mechanical Pressure on the Imbibitional and Drying Properties of Some Ceramic Clays, I," *Jour. Amer. Ceram. Soc.*, 15 [10], 552–63 (1932).

Fig. 1, the true volume of dry clay being 100 cubic centimeters in all cases. In addition, the plastic volume, the sum of the true volume of the clay and volume of plasticity water, and the dry volume of hand-molded briquets made at atmospheric pressure without pressing are plotted on the axis of zero pressure on the same basis, although they do not strictly represent what would happen at zero pressure in the permeable press. Curve *A* in Fig. 1 was plotted by means of the equation

$$Y = 271.5 - 35.2 \log_{10} X \qquad (1)$$

in which Y is the ordinate and X the abscissa. It shows a reasonably close fit with the solid dots representing the plastic volumes of the disk when in the press, particularly at the higher pressures, and indicates that, for the range of pressures investigated, the compression of the clay is approximately exponential in character, the volume decreasing about 10 cubic centimeters per 100 cubic centimeters of dry clay when the pressure is doubled. If this relation persisted at still higher pressures one would expect the water content of a disk of Florida kaolin to be approximately zero at about 75,000 pounds per square inch. The other curves in the figure have been drawn through the experimentally determined points.

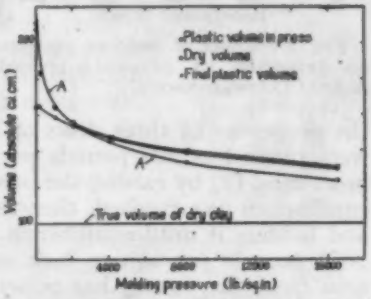

FIG. 1.—Effect of molding pressure on properties of permeable-pressed disks of Florida kaolin.

The curves in Fig. 1 cross each other in the neighborhood of the ordinate for 2500 pounds per square inch molding pressure. To the left of this point, the plastic volumes before and after the release of pressure are practically identical and follow curve *A*, and the dry volumes follow a flatter curve, the difference between the curves representing drying shrinkage. The slope of the dry-volume curve shows that, in this case, permeable pressing at pressures much too small to prevent substantial drying shrinkage nevertheless consolidates the clay to a greater extent than normal drying. This phase would bear further investigating. To the right of the neighborhood of intersection of the curves, the plastic volumes after release of pressure and the dry volumes are nearly identical, but the dry volumes are consistently smaller by an amount which is probably significant. This might be due to a minor constituent in the clay having a very high capillary suction or to a water film held tenaciously. The plastic volumes under pressure are lower than the final plastic volumes by an amount which increases with pressure. The increase in volume on release of pressure is probably due to clay particles recovering from elastic deformation, but other explanations are possible.

By comparison with the data plotted for hand-molded briquets on the axis of zero pressure, it will be seen that the total water remaining at high pressures is considerably less than the pore water at atmospheric pressure.

(2) Delaware Kaolin In Fig. 2, similar data are plotted for Delaware kaolin. In this case the curves intersect at a relatively low pressure, approximately 300 pounds per square inch.

At higher pressures, the dry volumes are practically identical with the final plastic volumes and there is no evidence of the residual shrinkage apparently shown by Florida kaolin. The increase in plastic volume on release of pressure is proportionately greater than with Florida kaolin. A curve of the type represented by equation (1) corresponded to a more persistent decrease in plastic volume under pressure with increasing pressure than was shown by the experimental data for Delaware kaolin.

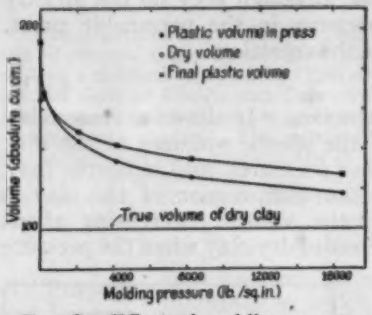
• Plastic volume in press
• Dry volume
• Final plastic volume
True volume of dry clay
Volume (absolute cu cm.)
Molding pressure (lb. /sq in.)

FIG. 2.—Effect of molding pressure on properties of permeable-pressed disks of Delaware kaolin.

(3) Nature of Equilibrium Although reproducible data could be obtained by approaching equilibrium always from lower to higher pressures, Terzaghi's,[2] investigations indicated that different moisture contents would be obtained by approaching equilibrium from higher rather than lower pressures. That this is the case is shown by the properties of three disks of Delaware kaolin, shown in Fig. 4, which were pressed at 207 pounds per square inch, (1) by following the usual procedure, (2) by raising the pressure to 414 pounds per square inch until equilibrium was reached, then reducing it to 207 pounds per square inch and holding it until equilibrium was reached, and (3) as in (2) but using 2070 pounds per square inch as the intermediate pressure. It will be seen from the figure that pressing at the higher pressures produces a consolidation which is not completely reversed when the pressure is released.

(4) Rate of Water Expression In the previous paper reference was made to the fact that in the permeable pressing of clay disks the approach to equilibrium took place in two stages. The first stage, during which most of the change in water content took place, was completed almost as soon as the pressure reached its final value; the second stage required several minutes but resulted only in a small water loss. This is illustrated by the curves in Fig. 3 which show the piston movement during the operation of pressing disks of Delaware kaolin about 1/4 inch thick, as recorded by a dial gage which registered the movement of the pistons toward each other. Readings of the dial gage were made at two-minute and sometimes one-minute intervals and are shown by the open dots in the figure. Movement of the

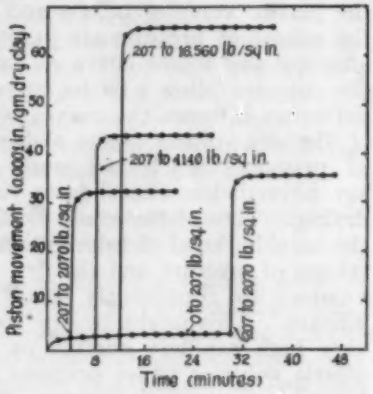
207 to 18,560 lb./sq in.
207 to 4140 lb./sq in.
207 to 2070 lb./sq in.
207 to 207 lb./sq in.
207 to 2070 lb./sq in.
Piston movement (0.0001 in./gm dry clay)
Time (minutes)

FIG. 3.—Rate of permeable pressing of Delaware kaolin.

[2] C. Terzaghi, "Principles of Soil Mechanics," *Eng. News-Rec.*, McGraw-Hill Publishing Co. (1926).

pistons was due not only to consolidation of the clay mass but also to compression of the gauze, filter paper, etc.

The curve on the extreme right illustrates the progress of a typical experiment following the standard procedure described in the previous paper. Equilibrium was reached at 207 pounds per square inch in about 22 minutes, was held for 8 minutes, and then the pressure was increased to 2070 pounds per square inch, an operation requiring nearly a minute. During this time, most of the total piston movement took place although further movement was shown for about five minutes. This second stage may be due to a dissipation of heat generated during the increase in pressure, to delayed crushing of clay grains, or to closer confirmation to the rough surface of the gauze. The other three curves show the piston movement on changing from equilibrium at 207 pounds per square inch to 2070, 4140, and 16,560 pounds per square inch with Delaware kaolin, the curves being started at different abscissas to avoid confusion. They are similar in general shape and indicate that a more rapid pressure change and continuous record would be needed to show the effect of pressure on rate of pressing. An apparatus has been constructed for pressing thicker disks which will be used for such a study.

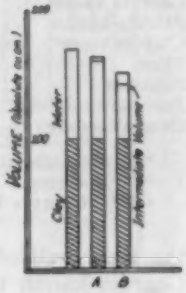

FIG. 4.—Effect of intermediate pressures on properties of permeable-pressed disks of Delaware kaolin. Final pressure 270 lb./sq. in. Intermediate pressures: $A = 2 \times$ final; $B = 10 \times$ final.

III. Effect of Permeable Pressing on Ceramic Mixtures

(1) Low Pressures The properties of disks made at 207 pounds per square inch by permeable pressing in accordance with standard procedure of several clays, a mixture of clays, two nonplastics, and a mixture of clays and nonplastics are given in Table I and shown graphically in the left half of Fig. 5. The properties of the wet disk consisting of 60% Georgia kaolin and 40% Florida kaolin by weight approximate those of Florida kaolin, but the dry disk has properties closer to Georgia kaolin. Little packing together of the two clays, however, has taken place.

The flint and feldspar disks were too fragile for volume determinations, and some doubt is attached to the moisture values since there was a tendency for air to blow through the disks when removing excess water from the press. The values given may therefore be low. They indicate, however, that flint and feldspar have approximately the same pore space as the kaolins at low pressures. The properties of the disks made from a mixture of 30 Georgia kaolin, 20 Florida kaolin, 20 flint, and 30 feldspar (a mixture which might be expected to have the physical properties of an electrical porcelain body in the green and dry states) had quite distinct properties from those of the separate ingredients showing a pronounced packing effect reflected in smaller wet and dry volumes. The change in volume on drying is about half that of the clay mixture indicating that the nonplastics are having only a diluting effect. It is interesting to compare the properties of the porcelain mixture with those of Grossalmerode clay shown in the last line of the table. They agree very well except in drying shrinkage. This is of interest in view of the fact that

chemical analysis of Grossalmerode clay and other tests indicate that it has a nonplastic content approximating that of the porcelain mixture.

(2) High Pressures Similar data for the clays and mixtures when permeably pressed at 8280 pounds per square inch, following standard procedure, are given in Table II and shown graphically in

TABLE I

PROPERTIES OF DISKS MADE AT 207 POUNDS PER SQUARE INCH GROSS PRESSURE

(Weights in g./100 g. dry clay, vol. in cu. cm./100 cu. cm. dry clay)

Material	Dry solids (true specific volume)[a] (1)	Wet disk (weight of water) (2)	(3)	(total volume) (4)	(water volume) (5)	(air volume) (6)	Dry disk (total volume) (7)	Drying change (total volume (8)
Georgia kaolin	38.59	28.7	28.6	173.5	74.3	−0.8	170.6	− 2.9
Florida kaolin	38.50	32.5	32.5	184.1	84.7	−0.6	165.9	−18.2
Clay mixture[b]	38.55	33.1	32.2	182.2	83.6	−1.0	171.0	−11.2
Flint	37.95	26.9	26.9		≧71.0			
Feldspar	39.02	31.8	31.0		≧80.7			
Porcelain mixture[c]	38.57	21.2	20.8	153.2	54.2	−1.0	147.4	− 5.8
Grossalmerode	37.78	17.2	18.9	148.9	50.2	−1.3	130.5	−18.4

[a] In absolute cu. cm./g. at 25°C against brass weights in air, 100×.
[b] 60% Georgia kaolin, 40% Florida kaolin by weight.
[c] 30% Georgia kaolin, 20% Florida kaolin, 20% flint, 30% feldspar.

the right half of Fig. 5. At this pressure the properties of Florida and Georgia kaolin tended to coincide and mixing had little effect except to decrease the air volume or increase in volume on release of pressure. The flint and feldspar packed more closely than at the low pressures but were not affected by the pressure as much as the clays. The porcelain

TABLE II

PROPERTIES OF DISKS MADE AT 8280 POUNDS PER SQUARE INCH GROSS PRESSURE

(Weights in g./100 g. dry clay, vol. in cu. cm./100 cu. cm. dry clay)

Material	Wet disk (weight of water) (1)	(2)	(total volume) (3)	(water volume) (4)	(air volume) (5)	Dry disk (total volume) (6)	Drying change (total volume) (7)
Georgia kaolin	11.9	11.3	144.3	29.3	15.0	143.8	−0.5
Florida kaolin	11.7	12.0	140.4	31.3	9.1	138.6	−1.8
Clay mixture[a]	12.7	13.5	139.5	35.1	4.4	140.5	+1.0
Flint	22.3	22.5		≧59.2			
Feldspar	24.6	19.9		≧63.3			
Porcelain mixture[b]	9.9	10.6	128.3	27.6	0.7	128.5	+0.2
Grossalmerode	9.1	10.1	127.1	26.7	0.4	124.7	−2.4

[a] 60% Georgia kaolin, 40% Florida kaolin by weight.
[b] 30% Georgia kaolin, 20% Florida kaolin, 20% flint, 30% feldspar.

mixture again showed good packing properties and also a virtual lack of air volume. Its properties were now almost identical with Grossalmerode clay, the differences at low pressure probably being due to the differences in the properties of the plastic constituents, such differences tending to disappear at high pressures. It is rather suggestive that the two clays and the porcelain mixture, which are known to be high in nonplastic

ingredients, all showed little change in plastic volume on the release of pressure. The nonplastic particles may cause the clay particles to crush rather than deform elastically.

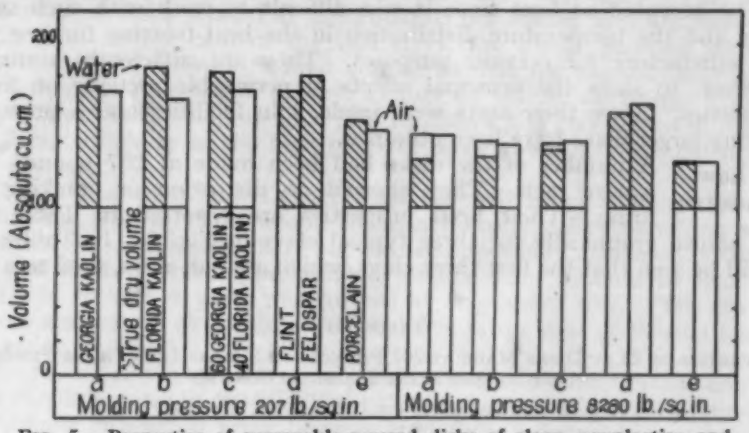

FIG. 5.—Properties of permeable-pressed disks of clays, nonplastics, and mixtures.

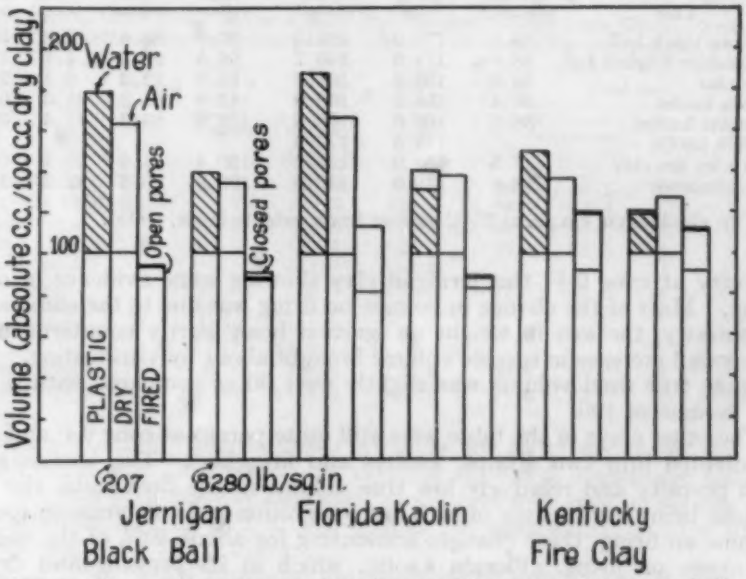

FIG. 6.—Comparison of properties of permeable-pressed disks of typical clays in the plastic, dry, and fired states.

IV. Preliminary Firing Tests

(1) Procedure In order to determine the effect of permeable pressing on the firing properties of a series of clays, a number of clay disks about $1^{3}/_{4}$ inches in diameter and about $^{1}/_{4}$ inch thick, which

had been made in connection with the investigation described in the previous paper, were packed in flint in a sagger and fired to cone 9+ in 16 hours in an electric heat-treating furnace. The values obtained should not be accepted as final since it was difficult to work with such small disks and the temperature distribution in the heat-treating furnace was not satisfactory for ceramic purposes. They are sufficiently accurate, however, to show the principal effects of permeable pressing on firing properties. Since these tests were made, kiln facilities and a press for making larger disks have been obtained.

(2) Low Pressures A number of the disks had been made at 207 pounds per square inch. They showed no distortion or cracking on firing. Their fired properties are reported in Table III and shown graphically for three typical clays in Fig. 6. In Table III, it will be seen that the first three clays, which are ball clays, fired to a low

TABLE III

PROPERTIES OF CLAY DISKS MADE AT 207 POUNDS PER SQUARE INCH GROSS PRESSURE BEFORE AND AFTER FIRING TO CONE 9+

(All volumes in cu. cm./100 cu. cm. dry clay)

Clay	Fired clay (true specific volume)[a]	Wet disk (total volume)	Dry disk (total volume)	Fired disk			
				(total volume)	(true volume)	(open pores)	(closed pores)
Jernigan black ball	38.5	178.0	163.5	93.9	88.4	0.3	5.2
Dorsetshire English ball	38.6	171.6	146.7	96.5	93.3	1.7	1.5
Vallendar	38.0	183.6	161.6	94.9	92.2	0.4	2.4
Florida kaolin	36.4	184.1	165.9	112.9	81.2	31.6	0.0
Delaware kaolin	36.5	168.6	166.8	124.8	83.3	41.4	0.1
Georgia kaolin		173.5	170.6				
Kentucky fire clay	37.5	150.0	136.3	120.4	91.6	28.4	0.4
Grossalmerode	38.6	148.9	130.5	108.9	95.3	12.2	1.4

[a] In absolute cu. cm./g. at 25°C against brass weights in air, 100×.

porosity at cone 9+, the Jernigan clay showing some evidence of over-firing. Most of the change in volume on firing was due to the elimination of porosity, the loss in weight on ignition being partly counterbalanced by a small increase in specific volume brought about by vitrification. The average true fired volume was slightly over 90 as compared with a true dry volume of 100.

The other clays in the table were still quite porous at cone 9+ and may be divided into two groups, kaolins and fire clays. The kaolins show high porosity and relatively low true volume in the fired state, the true volume being low because of high loss on ignition and a decrease in specific volume on firing, these changes accounting for about 40% of the volume shrinkage on firing. Florida kaolin, which in its pressing and drying properties resembled the ball clays, is quite distinct from them in firing properties after pressing at low pressure.

The fire clays, like the ball clays, show high true fired volumes due principally to low ignition loss, although Grossalmerode also shows a definite increase in specific volume on firing. Their small change in volume on firing, as compared to the ball clays, was due principally to their low dry volumes and high fired porosities.

(3) High Pressure It might be expected that the disks which were subjected to high pressure would show warping or lamination on firing. This, however, was not the case. The fired properties of disks pressed at 8280 pounds per square inch are shown in Table IV. In the case of the ball clays, the higher pressure resulted only in a slight decrease in fired volume so that the marked decrease in dry volume is reflected in a lower change in volume on firing. This is very evident in the diagrams for Jernigan black ball clay shown in Fig. 6, the firing shrinkage at the high pressure being about 65% of that at the low pressure.

The kaolins were still distinct from the ball clays although Florida kaolin was tending to approach them in porosity. By comparing with Table III, it will be seen that the increase in pressure decreased both the dry and fired volumes approximately by the same amount so that the change in volume on firing was lowered by only about 10%. The change in pore space from over thirty to about five in the case of Florida kaolin was quite striking.

The fire clays showed the same phenomenon of a simultaneous and almost equal decrease in dry and fired volumes due to the increased pressure, the volume change on firing being only slightly influenced.

TABLE IV

PROPERTIES OF CLAY DISKS MADE AT 8280 POUNDS PER SQUARE INCH GROSS PRESSURE AND 16,560 POUNDS PER SQUARE INCH BEFORE AND AFTER FIRING TO CONE 9+

Clay	Fired clay (true specific volume)	Wet disk (total volume)	Dry disk (total volume)	Fired disk			
				(total volume)	(true volume)	(open pores)	(closed pores)
		(8280 lb./sq. in.)					
Jernigan black ball	38.2	138.6	135.6	90.5	87.5	0.1	3.0
Dorsetshire English ball	38.7	138.8	138.4	95.1	93.4	0.2	1.5
Vallendar	37.5	150.8	148.4	93.2	91.0	0.6	1.6
Florida kaolin	37.3	140.4	138.6	89.1	83.3	4.4	1.5
Delaware kaolin		134.3	134.6				
Georgia kaolin	36.2	144.3	143.8	95.7	80.9	14.2	0.5
Kentucky fire clay	37.4	120.9	126.8	111.9	91.4	19.8	0.7
Grossalmerode	38.8	127.1	124.7	106.3	95.7	6.9	3.7
		(16,560 lb./sq. in.)					
Delaware kaolin	36.6	126.6	126.8	98.1	83.6	14.5	0.2
English china clay	37.0	126.9	133.0	91.3	83.6	7.7	1.2

At the bottom of Table IV, data are given for Delaware kaolin and an English china clay after permeable pressing at 16,560 pounds per square inch. At this pressure the Delaware kaolin had a change in volume on firing of about 70% of that at 207 pounds per square inch and the fired porosity was very much lower.

(4) Discussion of Firing Properties As a result of the preliminary firing tests, it may be concluded that no lamination or warping on firing were caused by permeable pressing of thin disks at low or high pressures. With clays which were fired to a low porosity, the decrease in dry volume obtained by permeable pressing resulted in a proportionately smaller change in volume on firing; with clays which were not fired to a low porosity, the decrease in dry volume on permeable pressing was reflected (sometimes completely) in a

decrease in fired volume, so that the change in volume on firing was not always decreased materially, although the fired porosity was greatly reduced.

V. Conclusions

(1) Molding Pressure A study of the relation between molding pressure and the properties of disks made by permeable pressing showed that with Florida kaolin the plastic volume under pressure decreased exponentially with increase in pressure, that all but a small persistent drying shrinkage was eliminated by pressures greater than 2500 pounds per square inch, and that lower pressures reduced the dry volume of the disks without preventing drying shrinkage. With Delaware kaolin, a pressure of about 300 pounds per square inch was sufficient to eliminate drying shrinkage completely, and the plastic volumes under pressure did not follow an exponential law over the whole range of pressures studied. With both clays at high pressure, a considerable increase in plastic volume took place on the release of pressure.

(2) Equilibrium Studies The plastic volumes of disks of Delaware kaolin permeably pressed at 207 pounds per square inch were less if the disks were first subjected to higher pressures.

(3) Pressing Rate The rate of water expression from disks of Delaware kaolin one-quarter inch thick was rapid at both low and high pressures, the process taking place in two stages.

(4) Mixtures A mixture of Georgia and Florida kaolin did not differ greatly in permeable-pressing characteristics from the clays themselves. A mixture of nonplastics and kaolins approximately in equal proportions by weight gave pronounced evidence at high pressures of the packing properties and lack of recoil on release of pressure which appear to be typical of fire clays having a high nonplastic content.

(5) Firing Tests Preliminary firing tests on permeable-pressed disks of ceramic clays about one-quarter inch thick showed no warping or lamination when fired to cone 9+. The decrease in total dry volume of the disks due to permeable pressing resulted in a marked decrease of firing shrinkage in clays fired to vitrification but resulted in a decrease in fired volume and porosity and little change in firing shrinkage with clays which were only slightly vitrified.

Acknowledgments The writer wishes to express his gratitude to H. B. Speakman, Director of the Ontario Research Foundation, for the facilities and help which made the investigation possible, and to F. J. Rutland, laboratory assistant, whose careful work is shown by the consistency of the data in the tables.

Ontario Research Foundation
43 Queen's Park
Toronto 5, Canada

THE USE OF TRIBARIUM ALUMINATE IN STRUCTURAL CLAY PRODUCTS*

By W. K. Carter[1] and R. M. King[2]

ABSTRACT

Tribarium aluminate was used in brick and sewer pipe, both on laboratory and plant scale tests. It was found to be efficient both as a scum preventive and as a producer of better density and color.

I. Introduction

The value of barium compounds for the prevention of scumming which results from migration of soluble salts to the surface of clayware has long been recognized. Practical application has been necessarily limited to those compounds which are available at a cost making their use possible.

The essential factors determining the availability of a barium compound are (1) the cost of treatment per ton of ware, (2) the concentration control necessary, and (3) the permissible variation in addition methods.

Within recent years present or anticipated industrial demands have resulted in the production of some barium salts which formerly were available only in limited amount or at prohibitive costs. A number of barium compounds were used in the course of this investigation, but preliminary work showed that only one, tribarium aluminate, offered promise of meeting the requirements of commercial application. The majority of the tests were accordingly made with this material and only these tests are being reported.

II. Tribarium Aluminate

The tribarium aluminate used has the empirical formula $3BaO \cdot Al_2O_3$. This product is uniform in composition. The total hot water solubility ranges from 70 to 72%, making available about 17% Al_2O_3 and from 45 to 50% BaO.

Note: The rate of solubility and hydrolysis will vary with condition but no effort was made in commercial trials to control these results because if close control was considered necessary the adaptability of the salt would be greatly minimized, and this would soon become evident in the series of trials planned. Laboratory work, however, is being carried on to determine these values and may lead to significant information, but the determinations are rather complicated and the work has progressed so slowly that nothing in the nature of a definite report can be given at this time.

III. Types of Experiments

(1) Laboratory The plastic trials were wrapped with tinfoil or greased so that drying progressed only from one surface. Drying and shrinkage determinations were made in laboratory driers. Other physical properties were determined by the standard test methods.

(2) Plant It was recognized that the type of clay, type of ware, addition method, and other factors might contribute either to the success or failure of the material in plant trials. The effective minimum additions could be determined only by making several trial tests.

The majority of trials were made at plants already using some barium

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[1] Ceramic Engineer, National Aluminate Corporation, Chicago, Illinois.

[2] Department of Ceramic Engineering, Ohio State University, Columbus, Ohio.

salt and in such cases the method of addition in practice was followed. For trials made at plants where no barium addition was used, means were devised or apparatus installed permitting accurate additions. At some plants the amount of tribarium aluminate used was equivalent to the amount of barium salt being used in practice. At other plants additional amounts were progressively decreased. In all cases the weight of salt addition per ton or unit quantity of ware was accurately measured.

IV. Plant Test Results

No. 1 Ohio shale, face and common brick; *practice:* dry addition, 4 lb. $BaCO_3$/M; *trial:* $1^1/_4$ to 3 lb. tribarium aluminate/M; *result:* satisfactory over the range of concentrations.

No. 2 Ohio shale, face brick; *practice:* dry addition 8 lb. $BaCO_3$/M; *trial:* 2 to 18 lb. tribarium aluminate/M; *result:* satisfactory over range of concentrations.

No. 3 Illinois shale, face brick; *practice:* dry addition, 8 lb. $BaCO_3$/M; *trial:* 4 lb. tribarium aluminate/M; *result:* very slight scum on portions of the trial.

No. 4 Indiana shale, face and pebble brick; *practice:* dry addition, 10 to 18 lb. $BaCO_3$/M; *trial:* 4 to 9 lb. tribarium aluminate/M; *result:* cold drier resulted in portions of the trial being scummed; 15% clear brick resulted from 4 lb. tribarium aluminate addition; this trial is being repeated under better conditions.

No. 5 Ohio shale mixture, face brick and floor slabs; *practice:* dry addition, 4 lb. $BaCO_3$/M; *trial:* 2 lb. tribarium aluminate/M; *result:* satisfactory.

No. 6 Ohio surface clay, common brick and hollow tile; *practice:* no barium salt additions made previous to these trials; *trial:* dry addition, 5 to 15 lb. $BaCO_3$/M; dry addition, 5 to $12^1/_2$ lb. tribarium aluminate/M; addition in tempering water, 5 to 15 lb. $BaCO_3$; addition in tempering water, $2^1/_2$ to 35 lb. tribarium aluminate; *result:* dry additions gave badly scummed ware with the 15-lb. $BaCO_3$ concentration; dry additions gave slightly scummed ware with the $12^1/_2$-lb. tribarium aluminate concentration; tempering water additions gave badly scummed ware with the 15-lb. $BaCO_3$ concentrations, approximating results of 6 lb. tribarium aluminate; tempering water additions using tribarium aluminate gave satisfactory results from $12^1/_2$ to 35 lb./M. (These brick were sold as face brick and samples were also weathered for six months through winter and spring showing no efflorescence. Other peculiar results which will be described later were noted in this trial.)

No. 7 Ohio fire clay, sewer pipe; *practice:* dry addition, 3 lb. $BaCO_3$/T.; *trial:* $1^1/_4$ lb. and $2^1/_2$ lb. tribarium aluminate/T.; *result:* satisfactory glaze, no apparent alteration of desired physical properties.

No. 8 Ohio shale, sewer pipe; *practice:* addition in cold tempering water of 3 to 4 lb. $BaCO_3$/T.; *trial:* cold water addition, 1 to 3 lb. tribarium aluminate/T.; hot water addition, 1 to 3 lb. tribarium aluminate/T.; *result:* 1 lb. cold water addition, scummed; $1^1/_2$ to 3 lb., satisfactory; 1 to 3 lb. hot water addition, satisfactory; no alteration in desired physical properties.

No. 9 Ohio surface clay, soft-mud face brick; *practice:* addition of a hot solution of barium chloride; this clay scums badly but runs fairly uniform; the chloride concentration is kept at the required minimum and scummed brick resulting from nonuniformity of clay are sold as specials; *trial:* identical concentrations of tribarium aluminate and barium chloride; *result:* satisfactory; no further effort has yet been made to lower the tribarium aluminate concentration.

No. 10 mixture of Missouri clays, sewer pipe; *practice:* no barium addition was made, previous experimentation showing no beneficial results; *trial:* 5 lb. and 10 lb. tribarium aluminate/T.; *result:* marked improvement in the ware, glaze being considerably heavier and glossier.

No. 11 Ohio fire clay, glazed tile; *practice:* dry addition, 6 lb. $BaCO_3$/T. (witherite); *trial:* salt-glazed shapes, 1 to 6 lb. witherite/T.; 1 to 6 lb. tribarium aluminate/T.; no addition; *result:* no evidence of soluble salt effect on any of the trials. Weathering treatment resulted in slight evidence of efflorescence in the no-addition and 1-lb. and 2-lb. witherite trials; this, however, did not progress to a point where it could possibly be considered a commercial defect; the clay and water composition varies considerably at this plant and it was thought that at the time the trial was made conditions were most favorable for a comparative test but evidently this was not the case.

No. 12 Missouri fire clay, sewer pipe; *practice:* no barium addition made; *trial:*

dry addition, 5 lb. and 10 lb. tribarium aluminate/T.; *result:* no appreciable difference from practice.

No. 13 mixture of Missouri clays, sewer pipe; *practice:* concerned with a new mixture not in production except in connection with these trials; *trial:* treatment with other barium salts has resulted in unsatisfactory results; laboratory trials with tribarium aluminate showed elimination of glaze defects resulting in a heavy glossy glaze as compared with yellow mat surface obtained in other trials; these were followed up with a production trial which is in the progress of firing.

(1) Increase in Color Intensity At Plant No. 6 ware which was entirely free from scum at a concentration of $12^1/_2$ pounds of tribarium aluminate per thousand brick evidenced a considerable change in color intensity as the concentration of tribarium aluminate was increased over this amount. It was apparent that this increase was not due to a further cleaning of the surface or to a difference in firing but appeared to be due to a better dispersion of the iron-oxide content of the clay. This might possibly be an effect of the alumina gel formation brought about by hydrolysis of the tribarium aluminate. The effect has not been noted to an appreciable extent in other trials but no other trials have been concerned with a clay in any way similar.

(2) Fired Strength and Porosity Crushing strength and porosity trials in connection with some of the sewerpipe tests have shown no appreciable change over that obtained in regular practice. Trials are in progress to determine if there is any effect upon what is known as "yard deterioration."

V. Laboratory Results

(1) Drying and Warpage In all determinations it has been found that the introduction of tribarium aluminate results in a decrease in the drying rate in the early stages of drying but no appreciable delay in the ultimate drying time. This results in some clays in a material decrease in the warping tendency. The degree of this effect, of course, depends on the type of clay and the concentration of tribarium aluminate.

(2) Green and Fired Strength and Porosity Laboratory data offer no conclusive evidence that there is any change in these properties that can be predicted except in special cases. Thin sections have shown that there may possibly be some alteration of the structure due to a change in plastic flow in some cases. There are not enough of these, however, on which to base a conclusion.

(3) "Popping" Tendency It was noted during some experiments with a clay high in lime pebbles that after firing these pebbles appeared to have an extraordinarily heavy coating and preliminary trials indicated that these samples resisted "popping." A large series of trials were prepared from this clay which had lime pebbles ranging from 6- to 20-mesh in screen size. Various additions of different barium salts were made. Bars were molded and fired in a plant kiln and, after firing, were given a treatment which is most conducive to "popping," that is, they were stored in a damp atmosphere. At the end of a few weeks all of the bars containing pebbles coarser than 20-mesh were entirely disintegrated except those of the tribarium aluminate series which were of sound structure with only slight "popping" of the surface pebbles in the 6-mesh trials. This might be caused by some effect resulting from

the affinity of lime and alumina hydroxide. It is improbable, however, that there is a practical application of such addition because of the type of ware in which this defect is common.

VI. Discussion

Consideration of the composition of tribarium aluminate and of the results which have been obtained in the field where it has been tested make it evident that there is a possibility of its use in other branches of the ceramic industry.

Since some of the effects obtained are evidently not due to barium it might be of value to determine to what extent and under what conditions the alumina could be made to function advantageously.

VII. Conclusion

In view of the data reported it would appear that tribarium aluminate meets the required specifications of a commercially practical barium addition in structural clay products, offering advantages of materially decreased additions, the use of an addition of a soluble salt not requiring exacting control, and no special method of addition. Other advantages of more or less practical importance are also indicated which are not usually associated with barium additions.

National Aluminate Corporation
Chicago, Illinois

SOME PROPERTIES OF ENGLISH CHINA CLAYS*

By T. A. Klinefelter, W. W. Meyer, and E. J. Vachuska

ABSTRACT

A study is presented of some of the properties of fifteen English china clays in common use commercially in the United States. Data are presented which may be useful in making substitutions for these clays, as well as furnishing a basis of correlation of some of the properties. A study of the base exchange capacities shows a general relationship to the transverse strengths of the clays in the unfired state.

I. Introduction

Because of the use of English china clays in commercial whiteware bodies in this country it was considered desirable to make an intensive study of certain of their properties. While English china clays are relatively pure and have practically a common origin, they vary somewhat in intrinsic composition and they vary also depending upon the aging and purifying processes undergone subsequent to mining.

II. Materials and Methods

Fifteen English china clays were supplied either from stocks of importers or from stocks on hand at plants using them. All of the clays have been used industrially for some time and are considered good grades by their users.

Specimens 7 inches long by 1 inch cross-section for transverse-strength tests, and specimens 2 inches long by 1 inch cross-section for various other tests were made of each clay by the extrusion method. In all cases at least ten specimens were prepared for each test. Specimens for expansion measurements with the interferometer were cut from heated bars. Samples of all of the clays were heated in a laboratory kiln to cones 3, 5, 8, 11, 14, 18, and 23. Each heating was complete in itself and the total heating time was 20 to 30 hours, depending upon the final temperature. Specimens of equal parts by weight of potters' flint and clay were prepared also from each clay and treated as above.

The method of chemical analysis was, in general, that for refractories described by Lundell and Hoffman.[1] Thermal expansivity measurements were made from atmospheric temperature to 650°C with the interferometer.[2] Specific gravities were determined according to the methods of test given as standard in the Yearbook of the American Ceramic Society.[3] Plastic and dry volumes were obtained by kerosene displacement, and volumes of heated specimens by water displacement. The percentage volume shrinkage during both drying and heating was calculated on the basis of dry volume.

The specimens for water absorptivity determinations were soaked in boiling water for two hours and cooled in the water to room temperature during a period of 24 hours. In obtaining the transverse strengths the

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* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (White Wares Division). Revised copy received April 29, 1933.

[1] "Analysis of Bauxite and of Refractories of High Alumina Content," Bur. Stand., *Jour. Research* (RP 5), **1**, 91 (1928).

[2] Described in Bur. Stand. *Sci. Paper* No. 485, by G. E. Merritt.

[3] Yearbook of the American Ceramic Society, pp. 48–49 (1921–1922).

specimens were broken on a 5-inch span. The pyrometric cone equivalents (P.C.E.)[4] were determined in a surface combustion furnace, the rate of heating approximating the accepted standard.[5]

In order to determine the points of maximum deflocculation, slips (*i.e.*, water suspensions) of 5% clay were prepared with various sodium hydroxide contents varying from 0.15 to 0.50%, in intervals of 0.05%, based on the weight of dry clay. After standing 24 hours the suspensions were centrifuged at 1800 revolutions per minute for one hour and the slip showing the most turbidity was assumed to be at the point of maximum deflocculation.

To obtain an approximate separation of particles smaller than 1μ in diameter, 10 pounds of clay were mixed with 10 gallons of water to which had been added the correct amount of NaOH for maximum deflocculation. The mixture was blunged, allowed to settle for 48 hours, the suspension siphoned off and then run at a rate of approximately 300 milliliters per minute through a supercentrifuge (with a bowl diameter of two inches) at a speed of about 13,000 revolutions per minute. The maximum size of overflowing clay particles was about one micron in diameter. The overflow was again centrifuged at the same rate of flow but with a bowl speed of about 18,000 revolutions per minute. In this case the largest clay particles were visible under the microscope with a magnification of 1200 times but were not measurable with accuracy, and their average diameter was estimated, assuming the application of Stokes' law, to be about 0.7μ. The filtration of the overflow from the second separation was accomplished with a Pasteur-Chamberland filter. The conventional size division between colloidal and non-colloidal material[6] is about 0.1μ, but the percentage of total surface, represented by the size fraction between 0.1μ and 0.7μ, was considered too great to be neglected. Procedures adapted to the treatment of colloidal material were used in testing that portion of the clay collected on the filter. The final filtrate was discarded and the material collected on the filter tubes was removed and dried. A portion of this material was analyzed for the SiO_2:R_2O_3 ratio and another portion electrodialyzed for use in determining the -0.7μ material content of the clays by the water adsorption method. The percentage of -0.7μ material in the clay was calculated by dividing the water adsorption per gram of previously electrodialyzed dry clay by the water adsorption per gram of dry -0.7μ material and multiplying it by 100. Duplicate tests were made on all the clays and their separated -0.7μ fractions.

Electrodialysis and titration of the hydrogen-saturated clays was chosen as the most suitable method for determining the total electrodialysable base capacities of the clays. This is the same as the total exchangeable base capacity except for clays containing considerable amounts of the common salts.[7] The soluble salt contents of clays E and N were representative, being 0.12 and 0.11%, respectively. After the washing inci-

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[4] Interpreted according to the tentative definition given in the *Proceedings of the American Society for Testing Materials*, **30** [Pt. 1], 473 (1930).

[5] *A.S.T.M. Standards*, **30** [Pt. II], 210 (1930).

[6] Gile, *et al.*, "Estimation of Colloidal Material in Soils by Absorption," U. S. Dept. of Agriculture *Bull.*, No. 1193.

[7] "A Simplified Cell for Determining the Electrodialysable Base Content of Soils and Permutites," *Jour. Amer. Soc. Agron.*, **19**, 1015 (1927).

dental to preparation of samples, etc., only small amounts or traces were present. The cell used was that described by Bradfield.[7]

The electromotive force across each cell was 130 to 140 volts, which was sufficient to produce a direct current not exceeding 0.2 ampere, as advised by Wilson.[8] The electrodialyses were carried out on 10-gram samples and were continued until there was no apparent change in the current over a period of several hours. The total time required was from 20 to 30

TABLE I

COMPOSITIONS OF ENGLISH CHINA CLAYS[a]

Clay	Ignition loss (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	TiO_2 (%)	CaO (%)	MgO (%)	Na_2O (%)		K_2O (%)	Total (%)	Muscovite[b] (%)	Kaolinite[b] (%)	Free silica[b] (%)	SiO_2:-R_2O_3 of 0.7μ material
A	12.3	46.9	37.9	0.5	0.4	0.1	0.2	0.2		1.3	99.7	11.0	84.8	2.2	2.07
B	12.7	47.5	37.7	0.6	0.0	0.1	0.2	0.4		0.9	100.1	8.0	87.3	2.9	2.37
C	13.1	45.9	37.0	0.6	0.2	0.2	0.4	0.5		1.7	99.6	14.3	78.7	2.0	2.02
D	12.6	46.4	38.3	0.6	0.1	Tr	0.1	0.2		0.3	98.6	11.0	86.0	1.4	1.92
E	12.3	47.6	37.4	0.6	0.1	Tr	0.2	0.2		1.4	99.8	12.1	82.6	3.4	2.19
F	12.3	46.9	37.6	0.8	0.1	0.1	0.1	0.1		1.5	99.5	12.9	82.4	2.6	2.36
G	13.3	45.2	38.3	0.8	0.3	0.1	0.2	0.3		1.3	99.8	11.0	86.0	0.0	2.85
H	13.4	46.2	37.6	0.7	0.1	Tr	0.4		1.6[c]		100.0	10.5	84.8	1.5	2.24
J	13.4	46.4	36.8	0.8	0.1	0.2	0.2		2.1[c]		100.0	13.7	78.7	3.0	2.15
K	12.6	47.0	37.4	0.7	0.4	0.1	Tr	0.2		1.2	99.6	10.4	84.2	3.0	2.16
L	12.7	46.6	38.1	0.6	0.1	Tr	0.3	0.3		1.5	100.2	12.6	84.1	1.4	2.24
M	13.3	45.6	37.9	1.0	0.2	Tr	0.1		1.9[c]		100.0	12.5	83.6	0.9	2.14
N	12.3	47.7	37.6	0.7	0.1	0.0	Tr	0.3		1.4	100.1	11.9	83.5	3.4	
O	12.4	46.9	37.8	0.6	0.3	Tr	0.2	0.2		1.2	99.6	10.0	85.8	2.1	2.14
P	12.5	46.6	38.3	1.0	0.1	0.0	Tr	Tr		1.5	100.0	12.3	84.9	1.6	

[a] Analyses by J. F. Klekotka.
[b] Calculated from chemical compositions.
[c] Obtained by difference.

TABLE II

PYROMETRIC CONE EQUIVALENTS OF CLAYS AND CLAY-FLINT MIXTURES

Clay	Clays only	Clay 50% Flint 50%	Clay	Clays only	Clay 50% Flint 50%
A	34	28–29	J	33–34	28
B	34–35	28–29	K	34–35	29
C	33–34	28	L	33–34	28–29
D	34–35	29	M	33–34	29
E	34	29	N	33–34	29
F	34	28	O	33–34	29
G	34–35	28–29	P	33–34	29
H	34–35	29			

hours. The final current was, in every case, less than 0.03 ampere. The total exchange capacities of the clays were determined by electrometric titration of the hydrogen-saturated electrodialyzed samples, using one nonflushing calomel half cell and one bright platinum electrode, with 0.3 gram of quinhydrone added to each 100 milliliters of the suspension being titrated. Standard $Ba(OH)_2$ solution, 0.1605*N*, was used for titrating. Titration was carried past the inflection point of the curve,

[8] "Note on Use of Bradfield Two-Compartment Cell in Electrodialysis," *Soil Sci.*, **26**, 412 (1928).

electromotive force *vs.* milliliters of standard solution, or to an electromotive force of 0.04 millivolt which corresponds[9] with a p_H of 7.

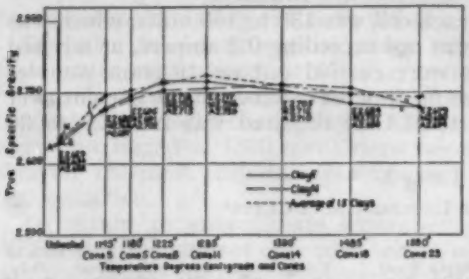

FIG. 1.—True specific gravities of clays E and N and the average of fifteen clays.

III. Results

(1) Chemical Compositions The chemical and calculated mineral compositions and SiO_2: R_2O_3 ratios of the -0.7μ fractions of the 15 china clays are given in Table I. The kaolinite in the clays varies from 78.7 to 87.3%; free silica content varies from 0 to 3.4%; rutile varies from 0.0 to 0.4%; and Fe_2O_3 varies from 0.5 to 1%.

(2) Petrographic Analyses The raw clays only were analyzed petrographically. The analyses show the whole group of clays to be similar in structure, invariably consisting of muscovite

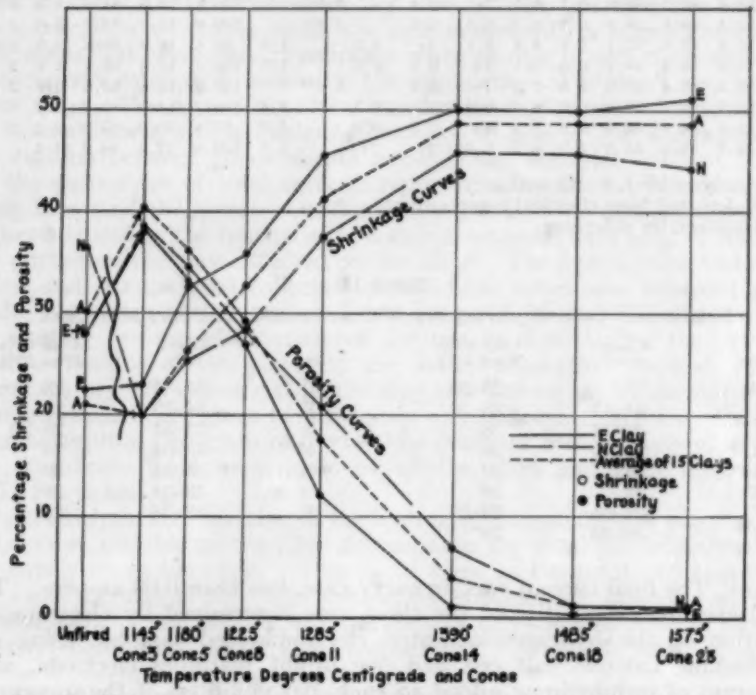

FIG. 2.—Volume shrinkage and apparent porosity of clays E and N and the average of fifteen clays.

[9] (*a*) Bradfield, "The Saturation Capacity of Colloidal Clay Soils," *Proc. First International Cong. Soil Sci.*, **4**, 858 (1927). (*b*) Baver, "Relation of Amount and Nature of Exchangeable Cations to the Structure of a Colloidal Clay," *Soil Sci.*, **29**, 291 (1930).

as the most abundant impurity, quartz present in small amounts, and traces of tourmaline. The kaolinite of clays A and B tended to be rather coarse grained, clay N was a mixture of coarse and extremely fine particles, and the remainder all tended to be fine while the aggregates were correspondingly large or small. Practically all of the mica grains in the clays were relatively coarse, and the quartz grains fine. If the size or shape of the clay particles affects such properties as transverse strength, it is probable from the similarity noted that the submicroscopic fractions are the determining factors.

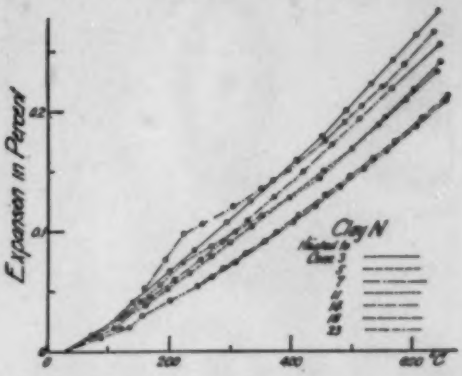

FIG. 3.—Linear thermal expansion curves for clay N heated to various temperatures.

(3) Pyrometric Cone Equivalents The P.C.E. of the clays alone averages 34 and that of the mixtures of flint and clay averages 5 to 6 cones lower. The values are given in Table II.

(4) Specific Gravity, Water Absorptivity, and Shrinkage The true specific gravity, apparent porosity (water absorptivity), and per cent volume shrinkage are shown in Figs. 1 and 2 for clay E, one of the stronger clays, and clay N, one of the weaker clays, as well as the average of all 15 clays.

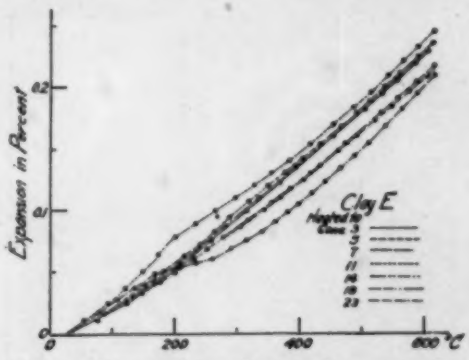

FIG. 4.—Linear thermal expansion curves for clay E heated to various temperatures.

The curves show that the average specific gravity increases slightly with higher heating to cone 11, after which there is no significant change. The volume shrinkage increases and the "apparent porosity" decreases with progressively higher heating to cone 14, and shows little further change after heating to cones 18 and 23.

(5) Linear Thermal Expansion Figure 3 is a graphic presentation of the data for clay N, one of the weaker clays, and Fig. 4 represents similar data for clay E, one of the stronger clays. It will be noted that there is relatively little difference in linear thermal expansion between these two clays, which is typical of the English china clays as a group.

The variations in expansion due to cristobalite are shown plainly (clay N, cone 7, and clay E, cone 11) and agree with the findings of Heindl, Pendergast, and Mong.[10]

[10] "Kaolins, Effect of Firing Temperatures on Some of Their Physical Properties," Bur. Stand., *Jour. Research*, 8 (R. P. 410) [2], 199 (1932).

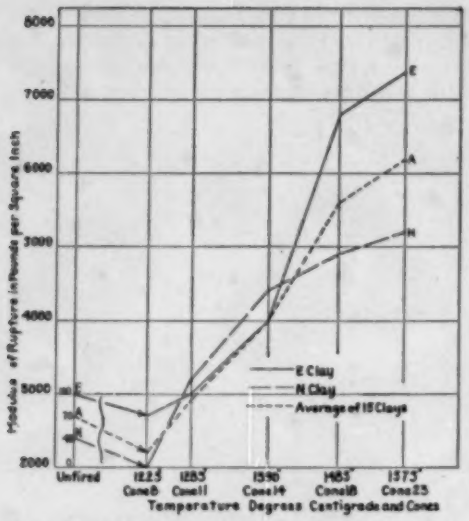

FIG. 5.—Transverse strength values for clays E and N and the average for fifteen clays; pure clays only.

(6) Transverse Strength Figures 5 and 6 show strength values for the two clays mentioned above, both alone and for the clays with an equal amount of flint. There is some indication in the data that the clay-flint specimens which are weak or strong in the dry state tend to remain relatively so through the various stages of heating.

(7) Deflocculation, -0.7μ Material Content, and Base Exchange Capacity The amount of NaOH required to produce maximum deflocculation of the clays varied from 0.25 to 0.50% of the weight of dry clay. Only one clay (P) required less than 0.30% and two clays (J and O) required more than 0.45% NaOH.

Figure 7 presents total exchangeable base capacity (in milli-equivalents per 100 grams of clay), percentage -0.7μ material and modulus of rupture of dry clay alone and of dry flint-clay mixtures. The clays are arranged in the order of increasing values[11] of total exchangeable base capacity. Sufficient filter separates for -0.7μ material content determinations could not be obtained from clays N and P by the method used, so values for these clays are not plotted. The values of the base-exchange capacities for the clays are given in Table III.

Figure 8 shows the general relation of the dry transverse strengths and total exchangeable base capacities of these

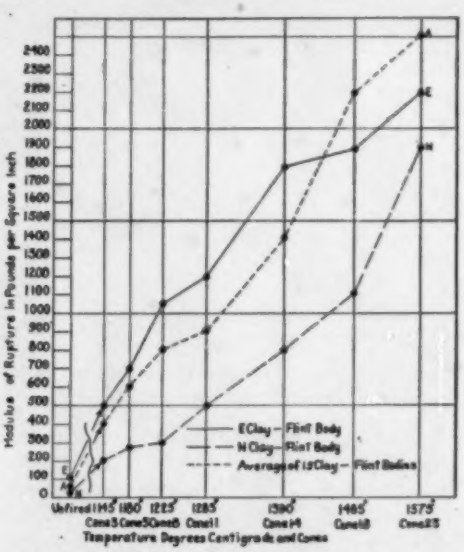

FIG. 6.—Transverse strength values for clays E and N and the average of all fifteen clays mixed with an equal amount of flint.

[11] These values, although obtained in a different manner, correspond to the *T* values given by K. Endell and P. Vogeler in their paper, "Der Kationen und Wasserhaushalt Keramischer Tone in rohen Zustand," *Ber. deut. keram. Ges.*, **13** [9], 378 (1932). See also footnote 13.

china clays, some ball clays, and some common clays,[12] and also that there is a general correlation of the exchange capacity with the dry transverse strength. The correlation is close enough to indicate that the exceptions may be due to experimental errors.

(8) Miscellaneous Tests Various other tests were made on the clays, but since the results failed to give any particular correlation with physical properties tabulated data are omitted. The water required to produce maximum plasticity varied between 37 and 48% of the dry clay. The p_H values of 5% suspensions in distilled water lay between 4 and 5.4. The slaking time of 1-inch cubes of the clays mixed 50–50 with potters' flint varied between 3 and 10 minutes. Grain size was determined according to the method of Scripture and Schramm.[13] It showed the quantity of material having diameters less than 1.7μ to vary between 38 and 66%. Determinations were made not only of modulus of rupture of the clay-flint bodies but also of bulk specific gravity, shrinkage, porosity, etc., after the various heat treatments. As these latter data give no additional information of significance they are omitted.

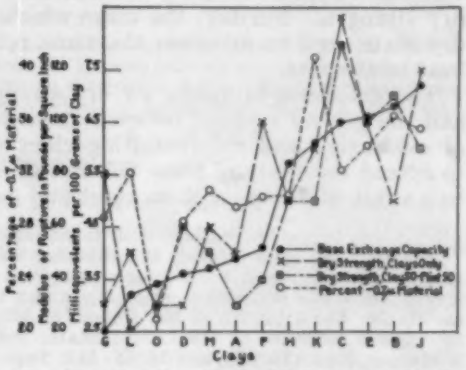

FIG. 7.—Total exchangeable base capacity (in milli-equivalents/100 grams), dry transverse strength (DTS: lb./sq. in.), and −0.7μ material (in per cent) of the English china clays (designated by letter).

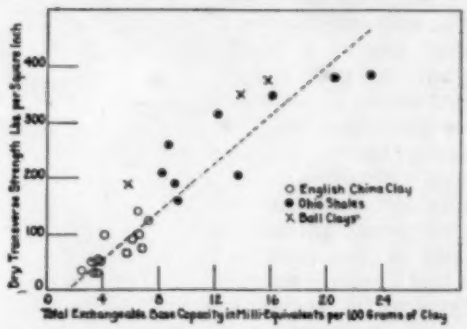
Dry Transverse Strength Lbs. per Square Inch
Total Exchangeable Base Capacity in Milli-Equivalents per 100 Grams of Clay
English China Clay
Ohio Shales
Ball Clays

FIG. 8.—Relation between dry transverse strength and total exchangeable base capacity of the English china clays, some Ohio shales, and some ball clays.

IV. Summary

Results of the chemical and petrographic analyses show all of the clays to be similar, the kaolinite varying from 79 to 87%, muscovite from 8 to 14%, and free silica from 0 to 3%. The P.C.E. values show no significant differences, averaging 34. This lack of difference is true also for the specific gravities of the dry clays which average 2.632 (true) and 1.45 (bulk) for the changes produced by heating, and for the linear thermal expansions of the heated specimens.

There is a marked difference between the extremes of values for moduli of rupture of the dry clays (maximum 140 and minimum 30 pounds per

[12] Determinations made in Columbus Branch Laboratories but as yet unpublished.
[13] Scripture and Schramm, *Jour. Amer. Ceram. Soc.*, 8, 243 (1925).

square inch) as well as for dry specimens of equal parts clay and flint (maximum 130 and minimum 20 pounds per square inch). Both the -0.7μ material content and the base exchange capacity vary considerably and there appears to be a relation between the latter property and the dry strength. Further, the clays which are weakest or strongest in the dry state tend to maintain the same relative positions after the various heat treatments.

The difference in values for dry strength and base exchange capacity and the general relation between these values seem to be the best means of evaluating and differentiating clays of the china type. It is hoped to extend the study of these features in future work, especially as applied to a study of domestic china clays and kaolins now in progress.

Acknowledgment The authors wish to acknowledge the assistance of J. F. Klekotka for making the chemical analyses; G. R. Shelton for the petrographic analyses; and K. E. Buck and Paul A. Bury for collecting data. The investigation was undertaken originally under the direction of S. J. McDowell while the station was a branch of the Bureau of Mines. The clay samples were supplied by various members of the United States Potters' Association as follows: Moore & Munger, Nos. 116, 333, and M. W. M.; Paper Makers Chemical Co., VC No. 1 and No. 25; English China Clays Sales Co., Nos. 1, 4, and 10; United Clay Mines Corp., Nos. 18A and 18W; John W. Higman Co., K15, K20, and No. 7; and Hammill & Gillespie, H & G and A1. These shipments were received in 1926.

THE BLISTERING OF CAST IRON ENAMEL*

Progress Report II

By Emerson P. Poste

ABSTRACT

This Progress Report II is a continuation of the report presented before the Enamel Division in 1932. The subjects discussed are (1) gases from metal, (2) possible reaction between enamel and iron, and (3) gases from the enamel itself. The author concludes in this report that nothing has developed which is inconsistent with the facts summarized in the 1932 report.

I. Introduction

In the discussion of Progress Report I[1] three possible causes for the blistering of cast-iron enamel were suggested as follows: (1) the reaction producing the gas may have taken place within the enamel itself; (2) a reaction between the metal and the enamel may have given off a gas; and (3) gas originating within the metal may have been driven out into or through the enamel.

Though possibilities (1) and (2) were not disproved, the evidence at hand was taken to indicate (3) as more probable. It was assumed that carbon oxide gases were produced in the iron either through oxidation by air or by iron oxide. Irons lower in total carbon and higher in silicon were found to have lesser blistering tendencies than those of the reverse nature. The more common type of blistering could be eliminated by the removal of the surface layer or micro-chill. But in the more extreme cases, usually involving low silicon and pearlitic structure, blistering was not eliminated by removal of the surface layer. Changes in combined carbon on enameling and supporting metallographic evidence indicated that irons which resist annealing are more prone to blister.

The application of a very thin coat of dry-process enamel to a severely blistering iron produced a violent bubbling phenomenon termed the "Manson effect." This is obviously the passing of a gas through the soft enamel without reference to the source thereof.

Subsequent work has been done along several lines directly bearing on the three possibilities outlined. Observations regarding the enamel itself as the possible source of the offending gas have been incidental to other studies. It is quite obvious that this can not be a general cause of trouble, the blistering tendency having been quite definitely proved to be related to the iron, either through causes (2) or (3). Work immediately subsequent to that covered in Progress Report I had to do primarily with the metal as the probable source of the gas. This was followed by attention to possible reactions between enamel and iron.

II. Gases from Metal

On the assumption that the oxidation of some form of carbon in the iron produced gases causing blistering, tests were made in which samples of iron were heated at controlled temperatures in atmospheres free from carbon dioxide, and any carbon oxide gases produced were quantitatively deter-

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* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (Enamel Division). Received April 19, 1933.

[1] *Bull. Amer. Ceram. Soc.*, 11 [8], 212 (1932).

mined. For this purpose a standard carbon combustion train was used, gases entering being freed from CO_2 by the usual means and the CO_2 produced being absorbed and weighed as in the determination of carbon in iron and steel by combustion. Small samples of suitable size and shape were placed in the furnace with a thermocouple near by to indicate temperature.

(1) Preliminary Tests For a preliminary comparison nonblistering iron 10–E and blistering iron 10–A were used. The former, unmachined as well as machined, had enameled without blistering and had exhibited no Manson effect. The latter had blistered badly, unmachined and machined, and had shown a pronounced Manson effect. The compositions of these two irons are as follows:

	10–E (nonblistering) (%)	10–A (blistering) (%)
Silicon	2.84	1.50
Sulfur	0.107	0.048
Phosphorus	0.70	0.18
Manganese	0.71	0.68
Total carbon	3.33	2.24
Graphitic carbon	2.94	1.43
Combined carbon	0.39	0.81
"FeO"	0.21	0.11

Samples of each of these irons, both bare and coated with enamel, were heated in the above-described apparatus in an atmosphere of CO_2-free air. The essential data are as follows:

CO_2-free air heated 13 min.; total CO_2 evolved.
Samples $^7/_{16}$ by $^7/_{16}$ by $3^1/_2$ inches, sandblasted.

		(°F)	(Gram)
Nonblistering	Bare	1100	0.0095
	Enameled	1100	.0095
	Bare	1300	.0545
	Enameled	1300	.0185
Blistering	Bare	1300	.0010
	Enameled	1300	.0000

At 1100°F, enamel not fused. Nonblistering iron, O. K.
At 1300°F, enamel fused. Blistering iron, badly blistered.

The essential facts to be noted are (1) that at temperature below enamel fusion CO_2 was evolved from bare and enameled iron in the same amounts; (2) that at temperature above fusion of enamel less CO_2 was evolved from enameled than from bare iron; and (3) that less CO_2 was evolved from blistering than from nonblistering iron, both bare and enameled, heated above enamel fusion temperature.

(2) Heating at Various Temperatures with Periodic CO_2 Weighings The positive results obtained in the preliminary tests led to a series of determinations on the rate of CO_2 evolution at different temperatures involving weighings at frequent intervals in each run to indicate the rate of evolution as related to time and temperature.

(a) Heating in Air The first set of tests covered heating nonblistering iron, bare and enameled, in CO_2-free air at various constant furnace temperatures. Samples were machined and presented

a 5.8-square inch area. The results of these runs are shown in Fig. 1 in which the rate of CO_2 evolution is plotted against time for the several indicated furnace temperatures. The obvious facts are as follows:

(1) Rate of CO_2 evolution from bare iron rises more rapidly with increase in furnace temperature.

(2) Consistent relation exists between the shape of curves.

(3) Melting of enamel apparently causes CO_2 evolution to cease.

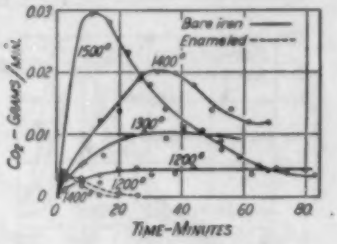

FIG. 1.—Heating nonblistering iron in CO_2-free air.

In the second set of tests, pieces essentially the same as those used in the first were introduced into the furnace at 500°F and heated to 1700°F at different rates. Figure 2 shows the results by the same scheme as in Fig. 1. It may be noted that (*a*) rate of CO_2 evolution from bare iron rises more rapidly with increasing rates of heating; (*b*) consistent relation exists between shape of curves; and (*c*) melting of enamel apparently causes CO_2 evolution to cease.

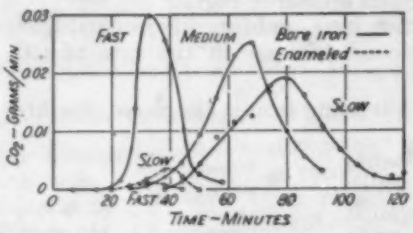

FIG. 2.—Heating nonblistering iron in CO_2-free air (varying rates).

The data used in Fig. 2 were plotted in Fig. 3 to show the relation between the rate of evolution and temperature for the several rates of heating.

With reference to Figs. 2 and 3, it is evident that the peak rate of CO_2 evolution from bare iron comes at higher temperatures and is greater in value with increasing rates of heating. The shape of the curves is relatively consistent. Enamel fusion stops CO_2 evolution.

At this point the supply of the former blistering iron, 10–A, had become exhausted and another blistering iron, 10–F, was substituted. The relative composition of the two irons is indicated as follows:

	10–A (%)	10–F (%)
Silicon	1.50	1.32
Sulfur	0.048	0.051
Phosphorus	0.18	0.15
Manganese	0.68	0.31
Total carbon	2.24	2.39
Graphitic carbon	1.43	1.47
Combined carbon	0.81	0.92
"FeO"	0.11	0.19

The new blistering iron, 10–F, had the same enameling characteristics as the former, 10–A.

The tests so far gave a general idea of the behavior of nonblistering iron heated from 500 to 1700°F. Data for blistering iron, 10–F, same size samples, heated in CO_2-free air from 500 to 1800°F are plotted in Fig. 4 with corresponding values for nonblistering iron shown for comparison.

Blistering iron, bare, gave slight CO_2 evolution around 1300° followed by a drop and, in turn, a rapid increase in rate.

Enameled blistering iron gave no CO_2 below enamel fusion temperatures, but rapidly increasing amounts as enamel coating failed due to overheating.

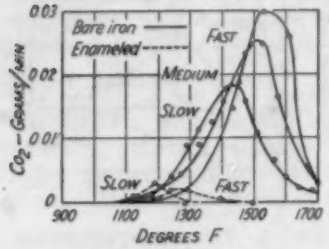

FIG. 3.—Heating nonblistering iron in CO_2-free air (varying rates). Pieces were introduced into the furnace at 500°C.

The dotted curve for nonblistering iron, bare, shows the marked difference between blistering and nonblistering iron.

In view of the slight increase in rate of CO_2 evolution for bare blistering iron at enameling temperatures, followed by cessation and rapid evolution in turn at higher temperatures, runs on bare nonblistering and blistering irons were made going up to 1900°F at a fast rate of heating. The samples were of the same size as before. The results appear in Fig. 5.

Heating bare nonblistering iron to higher temperatures than before shows a second increase in the rate of CO_2 evolution.

The general shape of the curve for blistering iron is the same, the first peak being much less pronounced.

In both cases the first peak represents the formation of a firm oxide coating which apparently temporarily protects against further oxidation until it breaks down on continued heating and comes off, exposing fresh iron at high temperature causing further CO_2 evolution.

Definite CO_2 evolution below enamel fusion temperatures should be noted. This tendency has been disregarded in plotting previous data. It varies from run to run. It probably comes from CO_2 admitted to the furnace during introduction of the sample, traces of organic matter on the sample, or CO_2 occluded on samples.

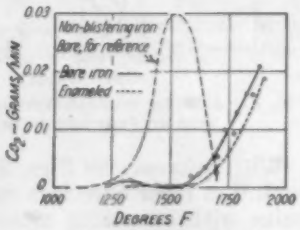

FIG. 4.—Heating blistering iron in CO_2-free air. Pieces were introduced into the furnace at 500°C.

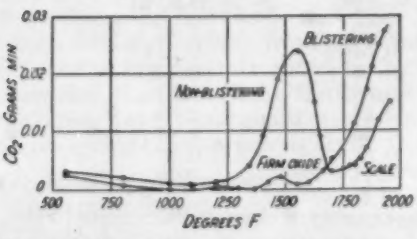

FIG. 5.—Comparison of nonblistering and blistering iron (bare) heated in CO_2-free air.

(b) Heating in Nitrogen The foregoing tests were taken as having established the behavior of nonblistering and blistering iron, bare and enameled, in CO_2-free air. Evidence pointed to oxygen from the air as the apparent essential factor for the evolution of CO_2. To prove this idea similar runs were made in CO_2-free nitrogen.

The results of these tests are shown in Figs. 6 and 7. The change in the scale for rate of CO_2 evolution should be noted. The facts are summarized as follows:

(1) Nonblistering iron, bare, gave traces of CO_2 below enamel-fusion

temperatures, none for a short higher temperature range, followed by rapid increase of rate.

(2) Enameled iron behaved similar to bare iron.

(3) Blistering iron heated in nitrogen gave less CO_2 below and above enameling temperatures than did nonblistering iron, both bare and enameled.

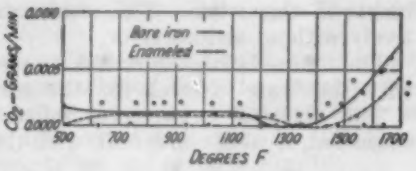

FIG. 6.—Heating nonblistering iron in nitrogen.

The evolution of definite amounts of CO_2 from both types of iron, bare and enameled, at temperatures above the enameling range in an atmosphere of nitrogen raises a question which has not been answered. Possibly there were traces of oxygen in the nitrogen which were active in small amounts at these higher temperatures. The point did not seem to warrant detailed study.

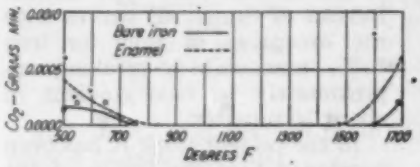

FIG. 7.—Heating blistering iron in nitrogen.

(c) Comparison with Bureau of Standards Work

In the foregoing tests the records have been made in terms of the rate of CO_2 evolution in grams per minute with the idea that this method would bring out the possible relations between CO_2 formation and various steps in the enamel firing cycle. The work of the Bureau of Standards involved plotting the cumulative CO_2 in milligrams against time in furnace. The chart involved (Fig. 7*a*) is reproduced from Research Paper, No. 179, page 793. To correlate the present work with that of the Bureau, additional tests were so made as to afford cumulative data.

Using the same size test pieces as before, runs were made on nonblistering and blistering iron, bare and coated with enamel. The results plotted to two different scales are shown in Figs. 8 and 9. The area of the Bureau of Standards test pieces was 5 square inches compared with 5.8 square

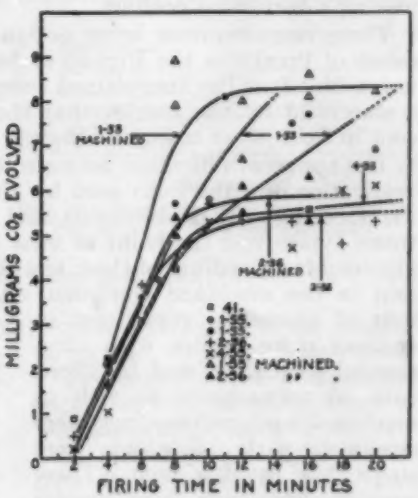

FIG. 7*a*.—Weight of evolved CO + CO_2 (calculated to CO_2) plotted against firing periods. All specimens completely coated with ground coat and fired at 875°C (1605°F) in CO_2-free atmosphere. Each point represents one specimen and the corresponding analytical determination. L_2, 1–55 is a strongly blistering iron, while all of the others (including L_2, 1–55 machined) are weakly blistering irons. (Bureau of Standards Diagram)

inches in this work. The results may therefore be considered quantitatively without serious error.

The "cumulative" curves for bare iron in Figs. 8 and 9 are consistent with the "rate" curves for the same irons in previous runs.

The relation between nonblistering and blistering iron, bare and enameled, is also consistent with the previous tests.

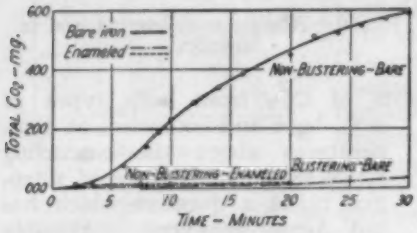

FIG. 8.—Heating nonblistering and blistering iron in CO_2-free air (1400°C).

In comparing Figs. 8 and 9 with the Bureau of Standards curves it must be noted that all the tests by the Bureau were on enameled iron.

Curves for enameled iron, Fig. 9, are of the same type as the Bureau of Standards curves with the exception of that for iron 1–55, unmachined, breaking approximately to zero gradient in about 10 minutes.

In the present work it has been concluded that the fusion of the enamel has blanketed the iron from the oxygen of the air preventing the further formation of CO_2. In the rate curves this is indicated by the rate returning to zero and in the cumulative curves by the line approximating a horizontal position.

These considerations bring out the possibility of enamel fusion as the cause of breaks in the Bureau of Standards curves, with that for 1–55, unmachined, as the unexplained exception. Bearing on this possibility is a statement by the Bureau that their enamels fused to a dense glossy coat in from seven to eight minutes.

The apparent difference between the nonblistering iron used in this investigation and the irons used by the Bureau of Standards emphasized the fact that the nonblistering and blistering irons involved are of extreme types from the point of view of enamel practice. Both had been obtained from castings of thick section and had been tested for CO_2 evolution in the machined condition only. To make possible studies on iron of enameling grade cast in sections more in line with commercial practice, and to afford data on unmachined as well as machined surfaces, castings were obtained, parts of which were strips $^3/_{16}$ by $^7/_{16}$ inch. These were available from three cupolas in a given shop: one producing iron definitely tending to blister, the second making iron with a lesser blistering tendency, and the third producing metal free from blistering. The compositions of these three irons are shown on p. 283.

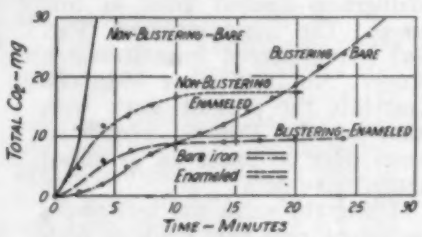

FIG. 9.—Heating nonblistering and blistering iron in CO_2-free air (1400°C).

There is nothing in the composition of these irons to suggest blistering in terms of the ideas developed in the first report. The silicon is a little low and the sulfur high in the worst iron.

On enameling with special enamel there was slight blistering on the worst iron; none on either of the others.

By using samples of these three irons of the proper length, areas of 5.8 square inches were obtained. In the unmachined condition these pieces presented the original surface at all areas but the ends. Tests were made in CO_2-free air, the iron being both bare and coated with enamel. The temperature was held at 1400°F. The results are indicated in Fig. 10.

	Best (%)	Worst (%)	Medium (%)
Silicon	2.89	2.34	2.89
Sulfur	0.094	0.128	0.088
Phosphorus	0.49	0.36	0.24
Manganese	0.64	0.42	0.60
Total carbon	3.36	3.30	3.41
Graphitic carbon	2.76	2.69	2.83
Combined carbon	0.54	0.60	0.56
"FeO"	0.19	0.19	0.19

The "best" iron gave off most CO_2, the "worst" and the "medium" in reverse of expected order.

Fusion of enamel apparently caused CO_2 evolution to cease.

Amounts of CO_2 evolved are small as compared with those for machined nonblistering iron (Figs. 8 and 9).

To determine the effect of removing the surface layer, tests were made on like samples of the best iron after machining, with the results shown in Fig. 11.

More CO_2 was evolved from bare iron than from the unmachined "best" iron, bare (Fig. 10), but not nearly as much as from the nonblistering iron in previous tests.

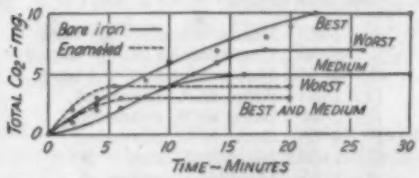

FIG. 10.—Heating special grid castings in CO_2-free air (1400°F, unmachined).

CO_2 was evolved from the enameled piece for a longer time than usual with less than previous difference between the bare and enameled samples for a given iron.

The nature of this iron was apparently quite different from the nonblistering iron, 10–A, previously used.

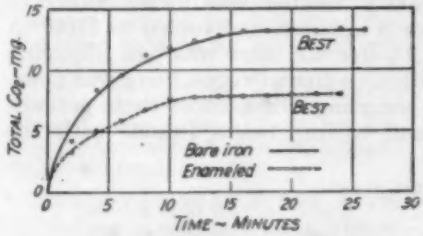

FIG. 11.—Heating special grid castings in CO_2-free air (1400°F, machined).

To make further comparisons with the work of the Bureau of Standards in the light of the foregoing information, samples of their strongly blistering, 1–55, and weakly blistering, 2–56 and 2–44, were obtained. To make samples of suitable size it was necessary to cut pieces from castings $^3/_{16}$ inch thick resulting in units with 67% of the surface unmachined and with areas of 3.8 square inches. Tests on these irons were run, partly machined as above, and wholly machined, bare and coated with enamel, as shown in Fig. 12.

A (1–55, strongly blistering) bare, shows more CO_2 than B and C,

weakly blistering irons. This is the first time that this has been the order of relation. The gradient for A is greater than for B and that for C is practically zero after 10 minutes. In D, E, and F CO_2 evolution stopped at enamel fusion. Totally machined 1–55 bare, curve G, shows much more CO_2 evolution than partially machined A. More effect from machining is noted than with the "best" iron (Figs. 10 and 11). Strongly blistering iron 1–55, enameled (curve D), broke to a horizontal position on enamel fusion as did curves for weakly blistering 2–56 and 4–55 (E and F) as compared with curves for unmachined 1–55 enameled (Bureau of Standards diagram), which did not break at the same time of heating as did the others.

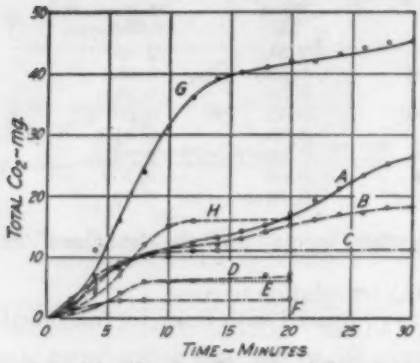

FIG. 12.—Heating Bureau of Standards Samples in CO_2-free air (1400°F).

A	1–55	Unmachined (67%) bare
B	2–56	Unmachined (67%) bare
C	4–55	Unmachined (67%) bare
D	1–55	Same as A, enameled
E	2–56	Same as B, enameled
F	4–55	Same as C, enameled
G	1–55	Machined, bare
H	1–55	Machined, enameled

1–55 "strongly blistering"; 2–56 and 4–55 "weakly blistering."

(d) Carbon Dioxide Evolution at Normal Enameling Temperature

No explanation of this discrepancy is at hand.

In the above tests most enameled samples had been heated beyond normal enameling temperatures and had been otherwise treated in a manner so far different from enameling practice that the final condition of enamel was not normal.

In an effort to determine the condition of the enamel and to obtain CO_2 evolution data from tests more closely approaching enameling conditions, tests were made on blistering iron with temperatures not exceeding those of enameling practice. As a preliminary step, enamel-coated samples were heated without determination of the CO_2 evolved. In each case the pieces were introduced into the furnace at 800°F, the temperature was raised to 1300° in 15 minutes, held at 1300° for 3 minutes, and cooled to 1100° in 10 minutes before removal. With CO_2-free air there was bad blistering on machined blistering iron while with CO_2-free nitrogen there was none.

Similar tests were made with CO_2 weighings for each of three periods, below fusion, fusion temperature, and cooling below fusion, with the following results:

	Heating in CO_2-free air		
Below fusion	900–1100°	8 min.	0.0011 g./min.
Fusion	1100–1300°	9 min.	0.0008 g./min.
Cooling	1300–1100°	12 min.	0.0003 g./min.
General blistering			
	Heating in CO_2-free nitrogen		
Below fusion	900–1100°	8 min.	No CO_2
Fusion	1100–1300°	9 min.	
Cooling	1300–1100°	13 min.	
No blistering			

(e) Relation between Blistering and Distribution of Iron Carbide

At this point the supply of blistering iron, 10–F, had become exhausted and another supply (10–X) of the same general type was obtained. A preliminary enameling test on this iron in normal air gave bad blistering on the unmachined surface but only slight blistering when machined. This was in contrast with the behavior of the former iron, 10–F, which had blistered as badly machined as unmachined. This introduced the fact that two irons supposedly of the same general type had different blistering characteristics.

An analysis of this iron gave the results shown, with those for the two former blistering irons, 10–A and 10–F, included for comparison.

	A (%)	F (%)	X (%)
Silicon	1.50	1.32	1.56
Sulfur	0.048	0.051	0.069
Phosphorus	0.18	0.15	0.17
Manganese	0.68	0.31	0.31
Total carbon	2.24	2.39	2.62
Graphitic carbon	1.43	1.47	1.52
Combined carbon	0.81	0.92	0.90
"FeO"	0.11	0.19	0.14

Though there were differences in composition they were not of an order to change the expected nature of iron X. It was later found that irons A and F were from the same source, X from another; also that A and F had been cast as round pieces 1.5 inches in diameter, X as plates $^1/_4$ inch thick.

The unexpected behavior of iron X led to further investigation as to CO_2 evolution and structural composition.

A test similar to those last recorded for 10–F was made. It was found that but small amounts of CO_2 were evolved when heated in air and none when heated in nitrogen. In air there was but slight blistering while in nitrogen there was none.

The results of these comparative tests on 10–F and 10–X are shown in Fig. 13.

(1) Blistering iron F (machined) blistered badly in air with slight CO_2 evolution; no blistering in nitrogen and no CO_2 evolved.

(2) Iron X, similar to F in analysis (machined), showed slight blistering in air with about the same CO_2 evolution as F under same conditions; no blistering or CO_2 evolution in nitrogen.

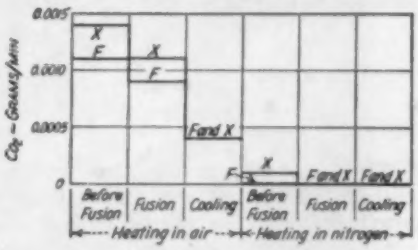

FIG. 13.—Comparison of blistering irons F and X heated in CO_2-free air and nitrogen. Iron F blistered badly in air; no blistering in nitrogen. Iron X blistering very slightly in air; none in nitrogen.

Samples of irons F and X received metallographic examination at the Laboratory of the American Rolling Mill Company. The structure of F was found to be quite uniform throughout: a pearlitic matrix with rather large areas of an irregular white constituent. Figure 14 shows the structure in general at 100 diameters, while Fig. 15 shows one of the large white areas and adjacent pearlite at 500 diameters. In iron X similar areas were less pronounced at the interior while a band of them was found

near the surface. Figure 16 shows the interior structure at 250 diameters and Fig. 17 the structure near the surface at the same magnification.

This comparison of these irons suggests a relation between the light areas and blistering. They are more pronounced on the interior of F than of X. F blistered badly at interior surfaces while X blistered but slightly on machining. Unmachined X blistered badly and these light areas were segregated just below the surface.

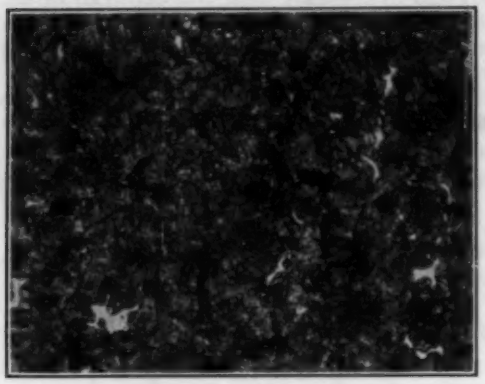

FIG. 14.—100×.

As to the nature of this light constituent, two possibilities have been suggested. Some have thought it to be cementite, while others have noticed certain etching patterns indicating eutectic structure and called the areas "complex carbides." The amount of phosphorus present is too low to produce steadite in an amount corresponding to the light areas under consideration. In either case the iron as a whole is hyper-eutectoid and the carbide constituents seemed to be related to blistering.

An effort was made to determine possible differences in chemical composition between the surface layer of iron 10–X as suggested in Fig. 17 and the metal below. A cut intended to remove the surface layer was taken, followed by another in the iron immediately adjacent. The partial analyses of metal from these two cuts and the corresponding values for the iron as a whole (drillings clear through the piece) are as follows:

	1st cut (%)	2nd cut (%)	Overall (%)
Silicon	1.60	1.50	1.56
Total carbon	1.95	2.39	2.62
Graphitic carbon	0.91	1.51	1.52
Combined carbon	1.04	0.88	0.90

These indicate material differences in total, graphitic, and combined carbon. The first cut differs from both of the others in these respects, lower total and graphitic carbon and higher combined, while the lower total carbon in the second cut as compared with that in the overall sample indicates that the second cut involved a condition intermediate between the surface and the interior.

(f) Summary: Gases from Metal

The results of the work on the possibility of gases from the metal as a source of blistering may be summarized as follows:

(1) CO_2 evolution tests have indicated a greater amount of CO_2 from bare, nonblistering iron heated in air than from blistering iron similarly heated.

(2) Enameled iron heated in air has shown essentially the same rate of CO_2 evolution as bare iron below enamel fusion range, but CO_2 evolution has quickly stopped at enamel fusion.

(3) Both types of iron have evolved traces of CO_2 when heated in nitrogen.

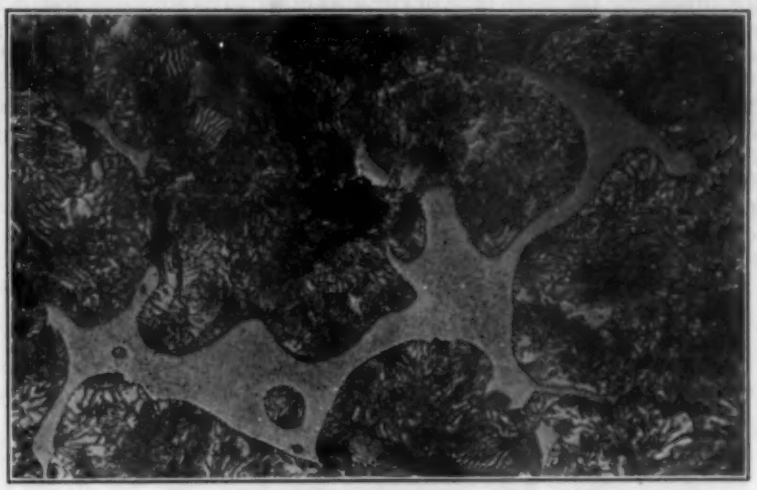

FIG. 15.—500×.

(4) A given enameling iron heated in air gave off more CO_2 machined than unmachined, bare.

(5) The Bureau of Standards type of cumulative CO_2 curve has been obtained only when heating enameled iron in air.

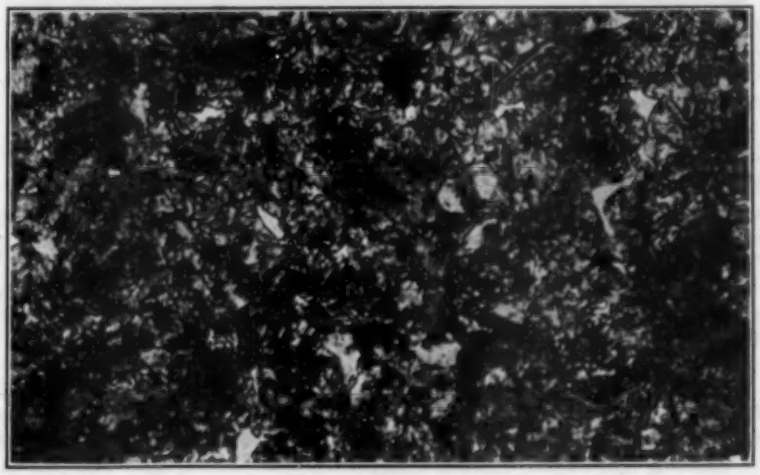

FIG. 16.—250×.

(6) The Bureau of Standards weakly blistering irons, unmachined, gave off CO_2 more rapidly bare than enameled when heated in air.

(7) The Bureau of Standards blistering iron, unmachined, gave off CO_2

at a fairly uniform rate, bare, through a heating range far in excess of normal enameling, but when enameled, CO_2 evolution stopped at enamel fusion producing the same type of curve as other irons similarly tested, and in contrast to the Bureau of Standards curve for blistering iron which indicated CO_2 evolution above enamel fusion range.

(8) Bureau of Standards blistering iron, machined, gave off more CO_2 bare and enameled, heated in air, than did the same iron, unmachined. The bare machined, unenameled iron did not show the sudden cessation of CO_2 evolution characteristic of enameled specimens.

(9) Irons rated as badly blistering in air did not blister in nitrogen.

(10) Of two special irons of similar composition, one blistered badly unmachined and machined, while the other blistered badly unmachined but

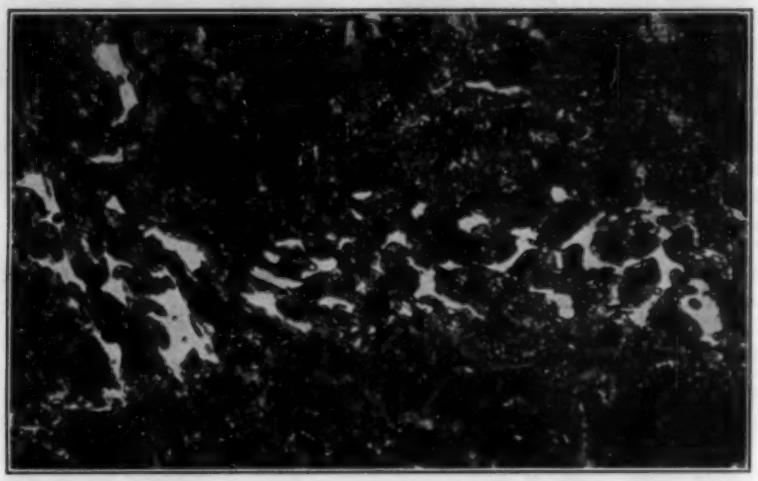

FIG. 17.—250×.

blistered only slightly machined. Metallographic examination of these two irons revealed relatively large amounts of light carbide areas throughout the entire thickness of the first iron, a concentrated band of these near the surface, with much less in the interior of the second.

(11) Analysis of the iron with pronounced carbide areas near the surface showed lower total and graphitic and higher combined carbon content in the surface layer than in the interior metal.

III. Possible Reaction between Enamel and Iron

The Manson effect was originally called to attention as evidence that in some cases a somewhat violent reaction between iron and enamel takes place. Further observations in support of this possibility were in relation to adherence. This point was also first noted by Manson in observing the difference in behavior of new laboratory sample plates as compared with others which had been repeatedly used and re-sandblasted. When tested for Manson effect the old plates were free from blisters while the new ones

produced a "fairly violent reaction when the enamel struck the hot surface." As to relative adherence Mr. Manson observed,

> To go a little further, however, after these plates were cool, I tossed them into the air, allowing them to drop flat on a concrete floor. The old plate which had enameled without any boiling chipped completely off when it first dropped, without any vestige of adhering enamel remaining. The new plate which gave the reaction between the enamel and the iron, after three drops on the floor, still had a large amount of remaining enamel on it, and in the spots where the enamel had come off a perfect lattice work of splinters remained clinging to the iron showing wonderful adherence.

From this he concludes that the reaction between enamel and metal which produces gas causing the Manson effect and blistering under normal conditions of processing also promote adherence of enamel to metal.

For check observations samples of new and old plates were submitted. Analyses of these irons were as follows:

	2–D (%) (new)	2–E (%) (old)
Silicon	3.03	2.53
Sulfur	0.086	0.094
Phosphorus	0.42	0.28
Manganese	0.61	0.56
Total carbon	3.45	3.43
Graphitic carbon	2.95	3.16
Combined carbon	0.50	0.27
"Ferrous oxide"	0.24	0.24

Based on the ideas developed in Progress Report I both of these irons should enamel without blistering. Samples enameled by the wet process did not blister, but Manson effect was noted on the new iron, both machined and unmachined, contrary to expectations. None was noted on the old iron.

The pieces used for the Manson-effect tests were enameled to a good finish and allowed to cool, following which they were compared for adherence by dropping carefully face up on a concrete floor, a distance of about three feet. On the second drop of the old iron (2–E), a large area of enamel came off leaving no slivers of enamel on the exposed iron. On ten drops of the new iron (2–D), the enamel cracked through to the surface at a small place, and after twenty drops only three small defects had developed. Slivers of enamel were firmly adhering to the partially exposed iron.

These observations definitely checked those of Mr. Manson. Iron exhibiting the Manson effect had shown marked adherence.

In a discussion of the above apparent relation between blistering and adherence it was suggested that certain types of iron might react with metallic oxides in enamel in such a way as to promote bond and produce a gas. Several tests were made in the hope of verifying this possibility.

As a preliminary approach to this phase of the problem, samples of iron which had been satisfactorily enameled were sandblasted and used in testing for Manson effect, blistering, and adherence, with different types of enamel. A commercial white cast-iron enamel produced no Manson effect or blistering and a powdered sheet-iron ground-coat frit gave no observed Manson effect, but was definitely blistered when melted down. Dropping the enameled pieces a distance of ten feet onto a concrete floor caused a bad shelling-off of the white cast-iron enamel, while the sheet-iron ground adhered well.

Like tests were then made using another cast-iron white enamel, a clear cast-iron glaze known to contain no antimony oxide, and a cast-iron black containing about 1.5% of heavy metal oxides. There was no Manson effect or blistering in any case but the drop test showed poor adherence in each instance.

The above result was taken to mean nothing as to the presence or absence of oxides but did again suggest that blistering and good adherence may be related.

After certain preliminary work with simple compositions, with and without lead oxide, the following enamels were prepared as a means of studying the possible bearing of lead oxide on the problem:

	1	1A	3	3A
SiO_2	50	50	40	40
Na_2O	25	25	23	23
B_2O_3	25	25	27	27
Fluorspar			10	10
PbO		10		10

These frits were used for dry-process application on two types of iron; the reblasted iron mentioned above and an iron known to blister badly. With the nonblistering iron there was no Manson effect and each enamel fired down to a good gloss without blistering. On the blistering iron there was a pronounced Manson effect with each enamel.

Considerable trouble was found in working these special enamels by the wet process but the final results were taken to be satisfactory in terms of the observations being made. On the nonblistering iron, enamels 1 and 1A tended to blister while 3 and 3A fired to a good gloss and texture. On blistering iron, enamels 1 and 1A blistered slightly, 1A less than 1, and 3 and 3A did not blister.

Tests for adherence again pointed to a positive relation between blistering and adherence.

The above indicates that, at least with these enamels and the special iron involved, the presence of lead oxide does not seem to be the cause of Manson effect, and that the use of enamels free from the several oxides under consideration does not prevent Manson effect.

Apparently enamels 1 and 1A had a slight tendency to blister, even on good iron. In neither case did the presence of PbO promote blistering; if anything it lessened blistering in enamels 1A and 1.

The above tests were made using lead oxide as the indicating material because this oxide is easily reducible. In view of the fact that it did not respond to possible reaction with the iron, it was concluded that at least on the basis of this general theory reaction between iron and enamel was not the cause of blistering.

The fact still remains, however, that there seems to be some relation between adherence, Manson effect, and blistering.

IV. Gases from the Enamel Itself

Though no separate work has been done on this phase of the problem, observations incidental to other studies have thrown light on this possibility.

In CO_2 evolution tests on enameled specimens some CO_2 has often been evolved at relatively low temperatures below enamel fusion. The enamel

may have been the source of some of this gas though definite amounts have been noted in connection with unenameled samples. This low temperature CO_2 may come from gas entering the furnace on introduction of the sample, the oxidation of organic matter on the sample, or the evolution of adsorbed gas on the iron or in the enamel. The lower temperatures are probably below those required to drive off any chemically combined CO_2.

In both air and nitrogen CO_2 evolution stopped quite suddenly upon enamel fusion and was not resumed until arriving at temperatures causing the destruction of the enamel, far above any commercial enameling temperature range.

No tests or observations have had bearing on the possible effect of any gas other than CO_2.

V. General Summary

In the work covered by this report nothing has developed which is inconsistent with the facts summarized as Part XIII of the previous report.[1] The general findings of the entire project may be stated as follows:

(1) Irons relatively low in silicon and high in combined carbon, especially those that are not readily annealed by the heat treatment incidental to enameling, are more prone to blister than those of the reverse nature.

(2) Blistering is apparently associated with the presence of certain carbon compounds at or near the surface of the iron. In extreme cases the conditions promoting blistering are so generally distributed throughout the casting as to be effective after the surface layer has been removed.

(3) Metallographic evidence has indicated that, in the case of badly blistering irons at least, free carbides are pronounced in the iron, and analytical data support this observation.

(4) Carbon dioxide evolution is in general more copious with nonblistering than with blistering irons when they are heated exposed to air.

(5) From iron coated with enamel carbon dioxide evolution practically ceases when the enamel reaches a temperature sufficient to cause fusion.

(6) Heating both types of iron in nitrogen results in essentially no carbon dioxide formation.

(7) Blistering iron when coated with enamel and heated in an atmosphere of nitrogen fails to blister.

(8) The last three statements indicate that oxygen from the air is necessary for the formation of carbon dioxide and blistering.

(9) These several observations point to a probable reaction between carbon in the metal and oxygen as related to blistering.

(10) Certain special cases offer analytical and metallographic evidence to indicate that the presence of iron oxide, generally distributed or segregated, may be a cause of blistering.

(11) The behavior of thin applications of enamel to hot castings of blistering iron has suggested a possible reaction between blistering iron and enamel, termed the Manson effect.

(12) Combinations of iron and enamel which have caused blistering and have shown the Manson effect have also developed superior adherence.

(13) An effort to account for these facts in terms of a possible reaction between blistering iron and metallic oxides in enamel produced negative results.

[1] *Loc. cit.*

(14) No evidence has been noted that would suggest the enamel itself as the source of gas causing blistering.

(15) No work has been done to determine a possible relation between blistering and gases other than oxides of carbon.

(16) The most logical statement in view of present knowledge is that (*a*) a reaction between oxygen in the air (or iron oxide within the castings in special cases) and certain forms of carbon in the iron produces carbon oxide gases which cause blistering; (*b*) that some irons are free from harmful amounts of this particular form of carbon, others contain it in a concentrated amount at the surface only, while in extreme cases it exists throughout the castings; (*c*) that the total amount of carbon oxide gases evolved at temperatures incidental to enameling is not related to blistering, but that minute amounts at certain critical periods which have escaped detection by the methods employed may be responsible for blistering; and (*d*) that coincident with these conditions is a reaction which promotes adherence of enamel to the iron.

These statements definitely indicate the type of iron most desirable for enameling which, in view of all the facts at hand, may be given as follows:

	Per cent
Silicon	2.60
Sulfur	Not over 0.080
Phosphorus	Varying with type of pig iron used
Manganese	0.50–0.60
Total carbon	Not over 3.40 .

These figures and good foundry practice should produce iron free from blistering of the type under investigation, and are based on the kind of castings usually involved in stove foundry practice. Changes in silicon content with corresponding differences in total carbon would be indicated for castings of other types.

99 MARKET STREET
CHATTANOOGA, TENNESSEE

CERAMIC ABSTRACTS

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Abrasives

Abrasive operation improves dies. Fred B. Jacobs. *Abrasive Ind.*, **14** [3], 11 (1933).—Accurate stampings are assured by grinding operation after heat treatment of the die. E.P.R.

Abrasives finish rubber molds. Anon. *Abrasive Ind.*, **14** [3], 16 (1933). E.P.R.

Abrasive wheel and its applications. W. R. Gutteridge. *Trans. Junior Inst. Eng.*, **41** [Part IV], 164–79 (Jan., 1931); abstracted in *Metals & Alloys*, **4** [1], 20 (1933).—Cylindrical, universal, and surface grinding machines are considered and a few safety suggestions and devices are mentioned. E.P.R.

Blasting with aluminous abrasive. Henry R. Power. *Metal Cleaning & Finishing*, **5** [3], 129–30 (1933).—The continued development of electrically fused alumina as the premier nonsilica air-blasting material has revealed a wide variety of applications where its use in replacing sand has accomplished not only sanitary and humanitarian ends but has also speeded up production. Some of the specific applications are discussed in detail. E.J.V.

Grinding wheel manufacture. Anon. *Can. Machinery*, **41** [13], 145–46 (1930); abstracted in *Jour. Inst. Metals*, **50** [2], 121 (1932).—The practice at the plant of the Dominion Abrasive Co., Ltd., is described. F.G.H.

Grinding machine for Widia tools. B. R. Rowland & Co. *Engineering*, **133** [3459], 511 (1932); abstracted in *Mech. Eng.*, **54** [7], 526 (1932).—This machine is fitted with three wheels for roughing, finish grinding, and polishing. F.G.H.

Spherical surface grinding. K. Seitter. *Werkstättstechnik*, **25** [20], 469–71 (1931); abstracted in *Mech. Eng.*, **54** [4], 309 (1932).—Methods of grinding spherical surfaces by means of internal grinding machines are described. F.G.H.

Use of grinding machine practice in manufacture and repair. P. W. Peel. *Indian & Eastern Eng.*, **69** [1], 59–65 (1931); abstracted in *Jour. Inst. Metals*, **50** [3], 193 (1932).—The interdependent progress of the motor industry, the grinding machine, and the development of the abrasive wheel present numerous problems of lay-out, maintenance, handling, and selection of abrasives and types of machine. Tool and cutter grinding, drill grinding, and the wet-grinding process are considered in detail. Various types of machinery are described and illustrated. F.G.H.

Hardening by grinding. George J. Murdock. *Amer. Machinist*, **76** [1], 7 (1932); abstracted in *Metals & Alloys*, **4** [1], 20 (1933).—It is often difficult to harden press tools without distorting them. Sometimes they may be hardened by grinding with a silicon carbide wheel filled with a mixture of beeswax and lard oil. E.P.R.

Grinding aluminum alloys. W. E. Warner. *Can. Machinery*, **42** [5], 30 (1931); abstracted in *Jour. Inst. Metals*, **50** [2], 121 (1932).—Wet grinding is recommended using silicon carbide wheels with a surface wheel speed of 5000 to 6500 ft./minute and a work speed of 75 ft./minute. Soda, together with water, kerosene, or grinding compound, is preferred as a lubricant. The coolant, which is repeatedly used, should be kept free from grit and chips by filtration in order to avoid surface scratches. F.G.H.

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[1] The abbreviation (*C.A.*) at the end of an abstract indicates that it was obtained from *Chemical Abstracts* by coöperative agreement.

The bold-face number following the journal name is the volume, the issue number is in brackets followed by the page numbers, then the year in parentheses.

Special grinding machine for eccentric disks. WEIL. *Werhzeugmaschine*, **36** [2], 40–41 (1932); abstracted in *Metals & Alloys*, **4** [1], 20 (1933). E.P.R.

Accurate surface grinding of castings. ANON. *Machinery*, **38** [10], 122–23 (1931); abstracted in *Metals & Alloys*, **4** [1], 20 (1933). E.P.R.

Grinding spinning cots on centerless grinders. ANON. *Abrasive Ind.*, **14** [3], 17 (1933). E.P.R.

Set-ups in centerless method. A. D. MEALS. *Abrasive Ind.*, **14** [3], 14–15 (1933).—Grinding of work such as shafts, balls, tapers, and pen barrels is described. E.P.R.

Polishing stainless steel sheets. C. C. SNYDER. *Sheet Metal Worker*, **23** [2], 80–94 (1932); abstracted in *Metals & Alloys*, **4** [1], 20 (1933).—The types of polishing and buffing wheels and polishing and buffing materials are specified for use on "Enduro" stainless steel. E.P.R.

Polishing stainless steel and iron. W. C. BREITING, E. F. BROWN, E. F. GLEASON, AND R. S. SCHWAEGERLE. *Machinery* [N. Y.], **38** [10], 764–65 (1932); abstracted in *Mech. Eng.*, **54** [9], 672 (1932).—Various types of machines for polishing stainless sheets and the determination of the size of abrasive and the buffing after polishing are described. F.G.H.

Polishing electric irons. ANON. *Abrasive Ind.*, **14** [3], 8–10 (1933).—The use of grinding by Westinghouse is described. E.P.R.

Polishing *vs.* plating standards. ERNEST LAMOUREUX. *Metal Ind.*, [N. Y.], **30** [4], 153–54 (1932); abstracted in *Metals & Alloys*, **4** [1], 20 (1933).—The proper polishing of the base metal before plating is essential for production of durable electrodeposits. E.P.R.

Preparation of the buffing wheel. F. A. W. LIVERMORE. *Metal Ind.* [London], **40**, 406 (1932); abstracted in *Jour. Inst. Metals*, **50** [6], 388 (1932).—There are five kinds of glue on the market, (1) skin, (2) bone, (3) horn-pith, (4) semi-horn pith, and (5) a mixture of skin and bone. Only the first is satisfactory. The preparation of the glue and its testing by means of the Cochell copper plate test are described. F.G.H.

First research station for the grinding and polishing industry. ANON. *Tech. Blätter deut. Bergwerkszig.*, **22** [1], 48–49 (1932); abstracted in *Metals & Alloys*, **4** [1], 20 (1933).—An illustrated description is given of the permanent exhibit of the newly established "Institut für Schleif- und Poliertechnik" at the Technische Hochschule of Braunschweig. E.P.R.

Investigation provides new deal. GEORGE P. PEARCE. *Abrasive Ind.*, **14** [3], 12–13 (1933).—The rearrangement of stand-grinder spindle speeds uses wheels to minimum diameter. E.P.R.

Present status of cemented carbide tools. M. F. JUDKINS. *Machinery* [New York], **38** [9], 643–49 (1932); abstracted in *Mech. Eng.*, **54** [8], 597 (1932).—The application of cemented tungsten-carbide tools to modern shop practice is discussed as well as the method of grinding cemented tungsten-carbide tool tips to break up chips. F.G.H.

PATENTS

Honing device for cylinders. JOSEPH SUNNEN. U. S. 18,763, March 14, 1933 (reissue).

Buffing apparatus. D. K. SINGER (B. F. Goodrich Co.). U. S. 1,899,427, Feb. 28, 1933.

Truing means for formed gear grinding wheels. E. W. MILLER (Fellows Gear Shaper Co.). U. S. 1,900,943, March 14, 1933.

Centerless grinding or polishing machine. R. W. FULLER (Production Machine Co.). U. S. 1,900,984, March 14, 1933.

Grinding machine. W. J. GUILD (Heald Machine Co.). U. S. 1,901,236, March 14, 1933. F. G. HUGHES (New Departure Mfg. Co.). U. S. 1,902,555, March 21, 1933. O. W. NELSON. U. S. 1,902,661, March 21, 1933.

Circular chaser grinding gage. W. J. HOGG (National Acme Co.). U. S. 1,901,242, March 14, 1933.

Method of making abrasive body. E. E. NOVOTNY (J. S. Stokes). U. S. 1,901,324 and 1,901,325, March 14, 1933. (1) A composition for the production of abrasive bodies comprises a liquid condensation product of phenol and formaldehyde, abrasive granules, and solidified carbon dioxide. (2) A composition for the production of abrasive bodies comprises abrasive grains having dry surfaces, the surfaces being coated with a dry and fusible synthetic resin and the resin surface being coated with a sticky synthetic resinous material.

Portable abrading and polishing machine. T. F. Brackett. U. S. 1,901,627, March 14, 1933.

Drum grinding machine. W. J. Andres (Bendix Aviation Corp.). U. S. 1,901,690, March 14, 1933.

Hob grinding machine. C. G. Olson (Illinois Tool Works). U. S. 1,901,926, March 21, 1933.

Machine for grinding axles, etc. V. P. Schmidt and H. A. Brenaman. U. S. 1,902,188, March 21, 1933.

Cylinder grinder. Joseph Sunnen. U. S. 1,902,194, March 21, 1933.

Abrading, polishing, or like surfacing tool. Alphonse Fiset. U. S. 1,902,844, March 28, 1933.

Cam grinding apparatus. C. G. Trefethen (Norton Co.). U. S. 1,903,149, March 28, 1933.

Pinhole grinding or honing tool. W. P. Roberts. U. S. 1,903,343, April 4, 1933.

Sickle grinder. Jack Brown and W. F. Reuter. U. S. 1,903,369, April 4, 1933.

Machine for grinding, polishing, etc. Lumsden Machine Co., Ltd., E. G. Blake, W. S. Lumsden, and J. H. Stanier. Brit. 387,838, Feb. 22, 1933.

Grinding or abrading machines. F. R. Barratt. Brit. 387,908, Feb. 22, 1933. Aktiebolaget Tonsor. Brit. 389,408, March 22, 1933.

Grinding or abrading elements. W. W. Triggs (Gardner Machine Co.). Brit. 388,034, March 1, 1933.

Face grinding or abrading elements. W. W. Triggs (Gardner Machine Co.). Brit. 388,035, March 1, 1933.

Process and apparatus for grinding and polishing the faces of saw blades of all kinds and similar laminar metal articles. E. Poeggel. Brit. 388,055, March 1, 1933.

Machine for grinding small bores or holes. J. Sunnen. Brit. 388,221, March 1, 1933.

Grinding machine for reconditioning copper form cylinders for intaglio printing. H. Schulte. Brit. 388,467, March 8, 1933.

Waterproof abrasive papers, cloths, etc. F. Simon. Brit. 388,585, March 8, 1933.

Device for feeding safety-razor blades to grinding and polishing machines. E. Siepmann, Jr., and M. Siepmann. Brit. 388,672, March 8, 1933.

Fabrication of spherical articles by grinding, polishing, etc. G. W. Rawlings, W. S. Davidson, and Hoffmann Mfg. Co., Ltd. Brit. 388,890, March 15, 1933.

Abrading or polishing tools. Bakelite G. m. b. H. Ger. 563,573, March 12, 1924. The method of Ger. 541,374 is modified by wetting the abrasive granules with furfural before mixing them with the phenol-aldehyde resin. Addition to 541,374, *Ceram. Abs.*, **11** [7], 398 (1932). (*C.A.*)

Art and Archeology

Use of selenium in glass. Anon. *Chim. & ind.*, **29** [3], 731 (1933).—Among the different varieties of selenium, the glass industry uses only the amorphous black and red varieties and the selenites of sodium, barium, and zinc. Selenium produces red melted glass, but has the property of removing the coloring caused by the presence of iron when added in small quantities. The red nuances vary from light pink to ruby red and yellow-red. Cadmium red is one of the chief new preparations; it is a cadmium sulfite in which a part of the sulfur is replaced by selenium. It is the ratio of the latter that determines the color tone of glass. Barium and zinc selenites are thin powders decomposing at a relatively high temperature. As decolorizers they are more powerful than sodium selenite. Zinc selenite is well adapted for the production of crystal glass, considerably increasing the limpidity of the glass. M.V.K.

Spraying of metals. Anon. *Metal Ind.* [London], **42** [9], 255–56 (1933).—Metallization, or metal spraying, is the process by which any metal or alloy capable of being drawn into wire and of being melted in any oxycoal gas, oxyhydrogen, or oxyacetylene flame is deposited by means of a special pistol on metal or any other surface. Details of procedure are given. M.V.K.

Progress in art of sandblasting glass in France. Anon. *Glass Ind.*, **14** [4], 44–45 (1933).—Photographs of gilded glasses depicting hunting and fishing scenes engraved with sandblast by J. J. K. Ray are presented. In these glasses, 10 to 13 mm. in thickness, the deep engraving is shown to best advantage by oblique lighting. The photographs were reproduced originally in *Glaces et Verres*, (see article by Gaëtan Jeannin, p. 219, this issue). E.J.V.

Ostwald color system. J. M. PRESTON. Presented at the Jan., 1933, meeting of the English Ceram. Soc.; abstracted in *Pottery Gaz.*, **58** [668], 197 (1933). E.J.V.

Colorimetry of pigments. G. F. NEW. Presented at the Jan., 1933, meeting of the English Ceram. Soc.; abstracted in *Pottery Gaz.*, **58** [668], 197–98 (1933). E.J.V.

Glassware treasures for sale. ANON. *Amer. Glass Rev.*, **52** [20], 9 (1933).—Glassware of the imperial Russian family is being shown in New York. E.P.R.

Museum "La Floridiana." LUIGI MOSCA. *Corriere Ceram.*, **14** [1], 3–15 (1933).—The history of the villa, "La Floridiana," near Naples and a description of the collection of fine ceramic ware of all countries and periods exhibited there are given. M.V.K.

Spanish glass artist. ANON. *Glaces et Verres*, **5** [30], 18–20 (1932).—Some of the highly artistic works of Louis Rigalt are described. Illustrated. M.V.K.

Greek pottery from Homeric Ithaca. W. A. HEURTLEY. *Illus. London News*, **182**, 45–47 (1933).—Early signed vases are among the discoveries of the British expedition's third campaign in the island home of Odysseus. 11 photographs. See also *Ceram. Abs.*, **11** [7], 400 (1932). H.H.S.

Book Review

The Study of Precious Stones. MAX BAUER. 3rd ed. Revised by Schlossmacher, Director of the Mineralogical Petrographical Institute of the University of Koenigsberg, Prussia. Reviewed by Felix Singer. Translated by F. A. Whitaker. 871 pp. Price 35 Rm. Bernhard Tauchnitz, Leipzig. The study of precious stones is an older science in America than in Germany. George Frederick Kunz's book, Gems and Precious Stones of North America, was a pioneer work in this field. A modern book dedicated to this study, such as Schlossmacher's 3rd edition of Bauer's The Study of Precious Stones should prove of interest to the American public. This edition represents a complete revision in the broadest sense and is a valuable reference book on precious stones. The points of contact between ceramics and precious stones are so manifold that the study offers much of interest to the scientifically inclined ceramist. The book is in two parts. One-third appeals in its fundamental scientific explanations to the ceramist as well as to the gem expert. It covers in great detail the crystal formation and measurements, the cutting and grinding, ease of cleavage, hardness, specific gravity, and optical properties, and leads to the methods of optical analysis of minerals such as occur in crystal formations developed in ceramic bodies. The optical methods used are described in great detail. Of special importance is the description of the magnetic, thermal, and physical properties and the description of their growth and solution because the processes involved are wholly analogous to those processes which are often of such importance in the formation of ceramic bodies. The remaining two-thirds of the book describe the individual gems covering their chemical composition, physical properties, occurrence, and distribution as well as the mining and production. The concluding chapter covers the cutting of gems. Similar processes used in different industries lead to progress; it is expected that the description of gem cutting will stimulate ideas which can find application in the grinding and cutting of ceramic ware. The book is profusely illustrated including colored plates of precious stones.

PATENTS

Design for jar. J. B. CLARK (Indiana Glass Co.). U. S. 89,437, March 14, 1933.

Design for plate, etc. YUKIO BUMA (Morimura Bros., Inc.). U. S. 89,482 to 89,488 and 89,490 to 89,501, March 21, 1933. GEORGE WESP (Rosenthal China Corp.). U. S. 89,522, March 21, 1933.

Design for coffeepot, etc. YUKIO BUMA (Morimura Bros., Inc.). U. S. 89,489, March 21, 1933.

Design for pitcher. C. B. ILGENFRITZ (U. S. Glass Co.). U. S. 89,525, March 21, 1933.

Design for casserole. CHARLES KAISER (Morimura Bros., Inc.). U. S. 89,527, March 21, 1933.

Design for cream pitcher. HARRY NEGBAUR (H. Negbaur & Co., Inc.). U. S. 89,529, March 21, 1933.

Design for sugar bowl. HARRY NEGBAUR (H. Negbaur & Co., Inc.). U. S. 89,531, March 21, 1933. C. B. ILGENFRITZ (U. S. Glass Co.). U. S. 89,561, March 28, 1933.

Design for refrigerator cabinet. J. R. REPLOGLE (Copeland Products, Inc.). U. S. 89,534, March 21, 1933.

Design for refrigerator top. J. R. REPLOGLE (Copeland Products, Inc.). U. S. 89,535, March 21, 1933.

Design for tumbler. C. B. ILGENFRITZ (U. S. Glass Co.). U. S. 89,562, March 28, 1933.

Cements

Place of cement fields in the system CaO–SiO_2–Al_2O_3(–Fe_2O_3). SERBAN SOLACOLU. *Zement*, **22** [9], 114–17 (1933).—Three types of cements can be distinguished according to their chemical compositions, (*a*) siliceous cements, (*b*) aluminous cements of the first type, and (*c*) aluminous cements of the second type. All cements (of every type) can be arranged in a definite field in Rankin's diagram of the 3-compound system, CaO–SiO_2–Al_2O_3, with corresponding consideration of the iron content. (1) Siliceous cements lie in the field $3CaO{\cdot}SiO_2$–$2CaO{\cdot}SiO_2$–$3CaO{\cdot}Al_2O_3$. (2) Aluminous cements of the first kind fall into the triangle $CaO{\cdot}Al_2O_3$–$5CaO{\cdot}3Al_2O_3$–$2CaO{\cdot}SiO_2$. (3) Aluminous cements of the second kind fall into the field $3CaO{\cdot}5Al_2O_3$–$CaO{\cdot}Al_2O_3$–$2CaO{\cdot}Al_2O_3{\cdot}SiO_2$. Rapid setting and breaking up was determined as a characteristic property of every type of cement. This property also belongs to a definite field in Rankin's diagram. (4) Curves of similar strength in the 3-compound diagram CaO–Al_2O_3–SiO_2 were recorded and from them a space diagram for the total field of cements was designed. M.V.K.

X-ray study of magnesium oxychloride cements. ANON. *Ind. chimique*, **20** [229], 147 (1933).—The Building Research Board (England) has just published the results of a physicochemical study of the system MgO–$MgCl_2H_2O$ completed by an X-ray study of different solid products obtained. It has been found that magnesium oxychloride cement is a porous nonhomogeneous body. In air, the hardened cement carbonizes on the surface and thus becomes immune to the action of humidity. Without it, it would decompose into hydrated oxide and a solution of diluted chloride. In practice, this is prevented by immunizing it with oil or wax. M.V.K.

Gaize cement. G. BAIRE. *Assn. intern. essai matériaux congr. Zurich*, **I**, 908–18 (1931).—Test results with gaize, a siliceous argillaceous rock, as raw material for cement are reported and compared with those of a high-class Portland cement. Gaize cement does not contain any free lime and is superior to Portland cement in corrosive resistance to vegetable and mineral oils, gasoline, weak acids, various chlorides, sulfates, and nitrates. See also *Ceram. Abs.*, **9** [9], 707 (1930). (*C.A.*)

Studies on aluminous cement. III. RENATO SALMONI. *Giorn. chim. ind. applicata*, **15** [2], 65–70 (1933); for Part II see *Ceram. Abs.*, **11** [6], 344 (1932). M.V.K.

Possibilities of formation of the compound $CaSO_4$ during cement grinding. PAUL SCHACHTSCHABEL. *Zement*, **22** [4], 45–49 (1933).—The requirements for the formation of different compounds of $CaSO_4$ are discussed on the basis of the newest researches. Changes of gypsum during grinding of cement in a laboratory and industrial mill are described. M.V.K.

Hydrated dicalcium aluminate. HENRI LAFUMA. *Ind. chimique*, **20** [229], 98 (1933).—L. studied the composition of the hydrated aluminates of calcium and found that alumina calcined at 600° is practically insoluble in cold hydrochloric acid (decinormal), while the aluminate is soluble. Twenty grams of cement were stirred in water for 1 hr., the filtered solution left to rest for several days, and the precipitate formed was collected. It was dried over calcium chloride, pulverized, and divided into 2 parts; one was treated with surplus hydrochloric acid, the other calcined to 600° and treated with hydrochloric acid. The insoluble alumina, aluminate, dissolved lime, and water were determined. It was found that hydrated dicalcium aluminate forms during the hydration of "ciment fondu." M.V.K.

Lime content and firing behavior of cement mixtures. D. STEINER. *Tonind.-Ztg.*, **57** [15], 171–73 (1933).—The amount of lime may be calculated from Kühl's formula, $CaO = 2.8SiO_2 + 1.65Al_2O_3 + 0.7Fe_2O_3$. A graph is given facilitating this calculation. Experiments were carried out to investigate the influence of lime on the clay contained in cement mixtures. It was found that it is not possible to correlate the amount of insoluble material and the quality of a cement. W.M.C.

Developing formulas for determining the "correct" lime content of cement. HANS KÜHL. *Pit & Quarry*, **25** [7], 36–44 (1933); see also *Ceram. Abs.*, **11** [2], 79 (1932). E.P.R.

PATENTS

High-strength calcined gypsum and process of manufacturing. W. S. RANDEL AND M. C. DAILEY (U. S. Gypsum Co.). U. S. 1,901,051, March 14, 1933.

Composition for molding investment inlays. M. C. DAILEY (U. S. Gypsum Co.). U. S. 1,901,052, March 14, 1933. A molding composition comprises a mixture of the following ingredients: finely ground silica 60 to 80%, alpha 20 to 40%, and a retarder to regulate the set with water.

Dental investment composition. M. C. DAILEY (U. S. Gypsum Co.). U. S. 1,901,053, March 14, 1933. An investment composition comprises a mixture of the following ingredients: alpha gypsum 40 g., powdered silica 60 g., and gum arabic $^1/_2$ g.

Dental model stone composition. M. C. DAILEY (U. S. Gypsum Co.). U. S. 1,901,054, March 14, 1933. A composition of matter suitable for use in the preparation of dental models comprises alpha gypsum and an amount of Rochelle salt sufficient to substantially overcome the setting expansion of the alpha gypsum.

Enamels

Enameling over rust. ANON. *Decorator*, **31** [1], 60 (1933).—Acid treatment sandblasting, and mechanical methods of derusting are described in detail. M.V.K.

Enamel as a protection against corrosion. H. KALPERS. *Glashütte*, **63** [7], 112–13 (1933).—The corrosion of metals, especially of cast iron and steel plate, is prevented by an enamel coat. This protection of the metallic surface depends on obtaining a uniform enamel layer without defects. The testing for cracks, adherence, corrosion stability, acid stability, etc., is described. M.V.K.

Washed-off enamels and their use. MATH. BECKER. *Emailletech. Monats-Blätter*, **9** [3], 23 (1933).—B. discusses the use of unfired enamel which has been washed from pieces which have been unsatisfactorily dipped or sprayed. He proposes several ways in which to collect this enamel and prepare it for use. The collection of the different kinds of scrap enamels, drying them, and remelting with new batches is one of the best solutions for the problem. E.J.V.

Antimony in hardware enamels. ANON. *Ministry of Health Memorandum; Chem. Trade Jour.*, **92** [2390], 200 (1933).—Three outbreaks of antimony poisoning due to the use of cheap low-grade enameled receptacles are reported. Antimony oxide is widely used in place of tin oxide as an opacifying agent in enameling because of its cheapness. The vessels in which lemonade was prepared were examined, and it was found that the enamel coating had been heavily attacked and disintegrated by the acid. The lemonade itself contained a large quantity of antimony in solution. M.V.K.

Metallography with polarized light. J. S. G. PRIMROSE. *Metallurgia*, **5**, 9–11 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 40 (1932).—Various fields for investigation using polarized light are indicated. F.G.H.

Degreasing metals by vapor process. E. V. D. WALLACE. *Metal Ind.* [N. Y.], **30** [2], 53–55 (1932); abstracted in *Mech. Eng.*, **54** [6], 455 (1932). F.G.H.

Sandblasting tests. ANON. *Indian Eng.*, **90** [3], 53 (1931); abstracted in *Jour. Inst. Metals*, **50** [2], 128 (1932).—Recent abrasion tests carried out by the American Hardware Corp. are described. Two hundred pounds of silica sand, alundum, and steel grit were used for sandblasting under service conditions until each material had lost its effectiveness. The steel grit showed an effective life of four times that of the alundum and seventeen times that of the sand, besides being much the cleanest abrasive tested and causing least labor and nozzle wear. The initial cost, however, is relatively high. F.G.H.

Relation between shape of grain and strength of sand. H. RIES AND H. V. LEE. *Trans. & Bull. Amer. Foundrymen's Assn.*, **3** [2] (*Trans.*, **39**), 857–60 (1931); abstracted in *Jour. Inst. Metals*, **50** [4], 268 (1932).—Clean sands were bonded with a strong ball clay and tested with varying degrees of hardness of ramming. Mixtures with rounded grains showed lower permeability and higher compression, in both the green and fired conditions, than those with angular grains. F.G.H.

Preparation and use of synthetic sand. L. B. KNIGHT. *Trans. & Bull. Amer. Foundrymen's Assn.*, **3** [1] (*Trans.*, **39**), 718–27 (1931); abstracted in *Jour. Inst. Metals*, **50** [4], 268 (1932).—The use of synthetic sand has increased extensively. Mechanical mixing coats the sand grains with the bonding material. Definite standards of permeability, bond strength, and moisture must be maintained. F.G.H.

Using Monel metal in pickling installations. A. JAESCHKE. *Glashütte*, **63** [8], 132–33 (1933). M.V.K.

Investigation of materials for molds in bronze casting. I. Raw materials. P. E. LIAMIN AND A. A. GINZBURG. *Liteinoe delo*, No. 3, pp. 9–12 (1930); abstracted in *Jour. Inst. Metals*, **50** [4], 268 (1932).—The factors determined were (1) proportions of the mixture, (2) influence of binders, and (3) influence of drying temperature. Strength and gas-permeability tests were used. Best results were obtained with a mixture of 3 parts lean sand and 1 part semifat sand. The optimum amounts of binders to be added

and the drying temperature (400 to 600°C) were also determined. The best results with mixtures of old and new sand were obtained with 30 to 40% of new sand. F.G.H.

Effect of temperature on the physical properties of metals. F. C. LEA AND C. F. PARKER. *Engineering*, **133** [3442], 23–26; [3443], 54–55 (1932); abstracted in *Mech. Eng.*, **54** [4], 310 (1932).—The effect of temperature and stress upon metals, and the phenomenon and measurement of positive creep in relation to temperature and stress are discussed. Secondary effects are of importance, especially in cases where metals are subjected to high-temperature conditions for long periods of time. F.G.H.

Why sheets are thicker at center. W. H. MELANEY. *Blast Fur. Steel Plant*, **20** [1], 61–63 (1932); abstracted in *Mech. Eng.*, **54** [4], 311 (1932).—The theory of the cause of greater thickness of sheet steel at the center is discussed. F.G.H.

Possibility of avoiding scaling of steel. J. CHANZY. *Rev. Métal.*, **29** [6], 281–300 (1932); abstracted in *Mech. Eng.*, **54** [10], 744 (1932).—The cause of scaling at heat-treating temperatures, the speed of cooling, and the influence of the thickness and composition of the metal are discussed. F.G.H.

Mechanical furnace for annealing and heat-treating medium and thick metal sheets. H. FEY. *Stahl Eisen*, **52** [25], 617 (1932); abstracted in *Mech. Eng.*, **54** [9], 669 (1932).—A continuous furnace with stationary roller hearths is heated with blast-furnace gas and is designed to introduce cold sheets onto refractory pillars and to heat them thoroughly on all sides. F.G.H.

Advantages of the use of oil firing in the enamel and glass industries. ANON. *Glashütte*, **63** [2], 28–30 (1933).—A new rotating drum kiln burning oil is described. On account of the continuous rotation, the melt is thoroughly mixed and heated uniformly so that a product is obtained of an absolutely uniform nature. M.V.K.

Foundry practice and equipment. P. W. PEEL. *Indian & Eastern Eng.*, **66**, 164–66; **67**, 68–70, 201–202, 337–40, 473–74, 609–11 (1930); abstracted in *Jour. Inst. Metals*, **50** [2], 122 (1932).—This is a series of articles on modern methods of plant maintenance, handling, and preparation of material. F.G.H.

American Rolling Mill and Ferro Enamel to build frameless porcelain house. ANON. *Enamelist*, **10** [5], 13 (1933).—A novel frameless enameled home to be exhibited at the Chicago Exposition is described. W.W.M.

Stran-steel house. ANON. *Enamelist*, **10** [5], 17 (1933).—An attractive $7000 house which will be shown at the Chicago Exposition is described. W.W.M.

PATENTS

Composition for refinishing enameled surfaces. GOTTLEB WELSCH. U. S. 1,903,346, April 4, 1933.

Vitreous enamels. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 389,436, March 22, 1933.

Electroplating. LANGBEIN-PFANHAUSER-WERKE G. M. B. H. AND ALFRED WOGRINZ. Austrian 129,078, Dec. 15, 1931. Metal articles are plated with Cr in known manner and then heated to 500 to 1200° to cause the Cr layer to sinter on. Layers of other metals may then be deposited on the Cr. (*C.A.*)

Enameling iron and steel, etc. LANGBEIN-PFANHAUSER-WERKE G. M. B. H. AND ALFRED WOGRINZ. Austrian 130,006, Dec. 15, 1931. The articles are first coated with Cr by electrolysis, either over the whole surface or over only the parts which are not to be enameled. The enamel is then applied, and the article is fired. Coatings of other metals may be afterward deposited on the exposed parts of the Cr coating. See preceding patent. (*C.A.*)

Enamels. HERMANN EISENLOHR (Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler). Ger. 560,497, Nov. 10, 1929. In the manufacture of white opacifying agents for enamels from materials containing Fe and Ti, the formation of colored impurities is prevented by preheating the materials to about 1100° with a small amount of H_3PO_4 or a soluble phosphate. (*C.A.*)

Enamels. HERMANN EISENLOHR (Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler). Ger. 563,227, April 15, 1931. The manufacture of white opacifying agents for enamels by the process of Ger. 560,497 (see preceding patent) is effected in the presence of the components of the enamel. The mixture is fused, ground, and applied in the powdered state to the article to be enameled. (*C.A.*)

Method of enameling metals, porcelain, etc., in tunnel kilns. TECHNOCHEMIE A.-G. Ger. 564,481, April 16, 1930. Operative features are described. (*C.A.*)

Glass

Relation between the composition and density and optical properties of glass. I. Soda-lime-silica glasses. G. W. MOREY AND H. E. MERWIN. *Jour. Opt. Soc. Amer.*, **22**, 632–62 (1932).—Measurements of d, n, and $n_F - n_C$ were made on 185 glasses in the region from mixtures intermediate between the RO, SiO_2 and RO, $2SiO_2$ ratios and pure SiO_2. The effect of heat treatment on d was studied and the condition of maximal d was chosen as the "corresponding state." The relationship between composition and property is discussed. No justification is found for the assertion that definite compounds exist in and determine the properties of the glasses. The Gladstone-Dale formula (for the additive relationship between composition and n) gave per cent departures little > one-half as large as those given by the Lorentz-Lorenz or Eykman formula, and one-third as large as those by the Lichtnecker formula. (*B.C.A.*)

Dielectric losses of glasses of different composition. F. KELLER. *Z. tech. Physik*, **14** [3], 128–31 (1933).—Replacing SiO_2 by CaO, BaO, and PbO decreases the losses considerably. BaO and PbO glasses show a minimum at 5%. MgO glasses show smaller losses than ZnO glasses. The increase of dielectric losses is very large if SiO_2 is replaced by Al_2O_3. An Fe_2O_3 content up to 5% will decrease the losses, whereas a higher Fe_2O_3 content will increase them. Replacing SiO_2 by B_2O_3 results in a small influence. It was found for several MgO glasses that the dielectric losses increase with increasing frequency (range 0.3 to 5×10^6 n). See also *Ceram. Abs.*, **11** [8], 448 (1932). W.M.C.

Study of the volatilization losses from glasses containing potash and silica. ERIC PRESTON AND W. E. S. TURNER. Presented at the Feb., 1933, meeting of the Soc. of Glass Tech.; abstracted in *Pottery Gaz.*, **58** [669], 349–50 (1933). E.J.V.

Specifications for raw materials in the glass industry. W. E. S. TURNER. Presented at Jan., 1933, meeting of the Soc. of Glass Tech.; abstracted in *Pottery Gaz.*, **58** [668], 218–21 (1933); for discussion see *Ceram. Abs.*, **12** [5], 185 (1933). E.J.V.

Decolorizing by selenium in batches containing a volatile constituent. M. PARKIN AND W. E. S. TURNER. *Pottery Glass Rec.* [Eng.], **15** [1], 20 (1933); see also *Ceram. Abs.*, **12** [4], 147 (1933). M.V.K.

Decrease in iron content of glass decolorized with selenium. ÉMILIO DAMOUR AND ALEXANDRE NADEL. *Compt. rend.*, **195**, 152–55 (1932); for abstract see *Ceram. Abs.*, **12** [3], 99 (1933). (*C.A.*)

Geometrical and physical properties of polished surfaces. G. SCHMERWITZ. *Physik. Z.*, **34** [4], 145–58 (1933).—Polished glass balls (as well as steel balls) with a diameter accurate within 0.1μ show irregularities caused by the polishing process. It was found that polished surfaces are also changing with time. The changes amount to a few thousandths of 1μ. They are explained by the Brownian movement of the surface layer which is assumed to be composed of colloidal particles. Glass surfaces which were obtained directly from the glass melt and not subjected to polishing exhibit spots which show no such disturbances and which will remain constant for long intervals. The same is true for well-polished plane surfaces. W.M.C.

Calculating the "working interval" of glasses. V. G. VOANO. *Keram. i Steklo*, **9** [1], 22–24 (1933).—V. discusses the paper of O. Knapp (*Keram. Rund.*, August 18, 1932) dealing with methods of calculating the temperature interval in which the glass is worked and concludes that Knapp's formulas are useless for practice. M.V.K.

Barium carbonate in the glass industry. ANON. *Chem. Trade Jour.*, **92** [2389], 186 (1933).—The brilliance and intensity of smalt (a potash glass containing cobalt oxide) are greatly improved by substituting barium carbonate for part of the silica. The fusion temperature of the smalt is lowered, and the mechanical properties of the finished glass are improved. The resistance of the translucent smalt to chemical attack is also increased. M.V.K.

Study of the reaction, $NaCl + NaHSO_4 + SiO_2 = Na_2SiO_3 + SO_3 + HCl$. O. K. BOTVINKIN AND T. E. GOLBA. *Keram. i Steklo*, **9** [1], 21 (1933).—The use of sodium chloride and sodium bisulfate for glassmelting is discussed. A mixture of corresponding substances taken in equivalent molecular proportion was heated in an electric furnace. The investigation of the reaction was made in temperature intervals between 150 and 900° and from 1000 to 1300°. The possibility of producing sodium silicate ($Na_2O{\cdot}2SiO_2$) from bisulfate, sodium chloride, and silica was proved by this experiment. M.V.K.

Melting glass for gage pipes for high-pressure boilers. B. S. GUREVICH AND M. N. LAGRANSKI. *Keram. i Steklo*, **9** [1], 15–17 (1933).—The chief components of the batch were sand, borax, kaolin, magnesia, and soda. It was found that a temperature not lower than 1360° was necessary to obtain a satisfactory glass because at lower temperatures the glass tended to devitrify. M.V.K.

Influence of metallic oxides on the coloration and light transmission of glass. K. FUWA. Abstracted in *Pottery Gaz.*, **58** [668], 221 (1933); see also *Ceram. Abs.*, **12** [5], 185 (1933). E.J.V.

Importance of specific-gravity determination for evaluation of soda suitable for glass batches. OSKAR LECHER. *Chem.-Ztg.*, **56**, 325–26 (1932).—In attempting to solve glass-manufacturing difficulties with various batches of soda, it was found that sodas with almost identical chemical composition differed widely in suitability for glass use because of differences in specific gravity. The following specific gravity limits are recommended: if the soda is pressed down, the optimum value is 1.4 and not lower than 1.3; for specific gravity determined by agitation 1.15 is the normal and 1.05 the low limit. (*C.A.*)

Etching of glass: sand and acid etching combined. GAËTAN JEANNIN. *Glaces et Verres*, **5** [26], 10–16 (1932).—J. describes a simple method for etching glass by means of acid etching and sandblasting combined (illustrated). M.V.K.

Actual experiences on the yellow by cementation. J. WOLF. *Céram. Verrerie*, No. 844, pp. 549–52 (1932).—In the process of coloring glass by cementation a solution of a silver salt in turpentine is applied to the ware and fused for two or three hours at about 650°C, the excess salt then being removed by washing. The yellow coloration resulting is due to a colloidal solution of silver in the surface layer of the glass. This color is very sensitive and its formation depends on (1) the form in which the silver is added, (2) the composition of the cementation mixture, and (3) the chemical composition of the glass. The work of Heinrich (*Ceram. Abs.*, **11** [11], 562 (1932)), Springer (*ibid.*, **11** [8], 446 (1932)), Salaquarda (*ibid.*, **11** [8], 445 (1932)), and Zsigmondy is discussed. M.H.B.

Rationalization in the chemical factory. New results in standardization of glass apparatus. H. H. FRANCK. *Chem. Fabrik*, p. 154 (1932).—Proposed specifications for rubber tubing are given. *Ibid.*, p. 340 (1932).—Proposals are made for a nitrometer and for reagent bottle labels. *Ibid.*, pp. 401–403 (1932).—Specifications for hydrometers and pycnometers are proposed. *Ibid.*, p. 18 (1933).—Specifications are offered for laboratory and plant thermometers. (*C.A.*)

Testing ampoule glasses. D. VON KLOBUSITZKY. *Kolloid-Z.*, **62**, 98–99 (1933).—Notes on testing are given. Glass which, when suspended in H_2O, does not raise the p_H above 9.5 is suitable. (*B.C.A.*)

Ultra-violet radiation and U-glass. HARALD LUNELUND. *Teknillinen Aikakauslehti*, **22**, 414–18 (1932).—A summary of the physical and biological properties of rays is given. Ordinary window glass does not begin to transmit ultra-violet light until the region of 310$\mu\mu$ is reached, while the new U-glass transmits at 260$\mu\mu$. In the region of the Dorno interval (320 to 290$\mu\mu$) the new U-glass transmits from 40 to 80% of the ultra-violet light. The importance of the Dorno interval in biological work is stressed. (*C.A.*)

Glass permeable to ultra-violet rays. J. LE BRAZ. *Glaces et Verres*, **5** [27], 12–16 (1932).—L. deals with (1) the solar spectrum, (2) invisible radiation, and (3) ultra-violet rays and glasses permeable to them. Information on a French glass, "Sanitalit," is given and its properties are compared to those of American, English, and German glasses. M.V.K.

Temperature measurements on wire glass. H. E. BECKETT. *Pottery Glass Rec.* [Eng.], **15** [1], 20 (1933); see also *Ceram. Abs.*, **12** [4], 149 (1933). M.V.K.

Slag glass. C. A. BASORE. *Mfrs. Rec.*, **102** [1], 68 (1933).—Blast-furnace slag is a cheap source of lime, alumina, and silica. Experimental results seem to indicate that liquid slag as it is discharged from the blast furnace can be converted directly into glass. Iron oxide in the slag and the sand (1% or more) mitigates the possibility of making colorless glass, but colored glass, pale green to medium or dark green, brown, or black, is readily made as desired. Slag glass is very tough. It draws readily into threads which are unusually elastic. Glass has a decided tendency to break in rounded fragments rather than in angular pieces. Slag glass has high tensile strength, good thermal endurance, and remarkable resistance to corrosion by hot water, hydrochloric acid, and sodium hydroxide. See also *Ceram. Abs.*, **11** [4], 234 (1932). E.P.R.

Use for "glass silk." ANON. *Pottery Glass Rec.* [Eng.], **15** [1], 8 (1933).—Glass silk is effective for deadening sound between rooms and as a heat insulator. It does not attract moisture and is odorless in all conditions. M.V.K.

Experiments in manufacturing high-grade glass insulator. H. SH. SHAKIROV AND L. A. MURAKH. *Keram. i Steklo*, **9** [1], 7–10 (1933).—Without preliminary treatment of the surface, glass insulators have a low surface resistance regardless of their composition and therefore do not have the necessary electrical properties. After treat-

ing them with boiling water, the glass insulators secured high insulating properties and could be used instead of porcelain insulators. M.V.K.

Cutting and shaping Triplex glass. A. F. *Glaces et Verres*, **5** [25], 14–16 (1932).—Methods for cutting and luting Triplex glass and the apparatus used are described. M.V.K.

Safety glass: laminated or Sekurit? WALTER OBST. *Glas und Apparat; Nat. Glass Budget*, **48** [44], 8 (1933).—Sekurit will undoubtedly find a place with laminated glass, but whether or not it will replace it is still a question. See also *Ceram. Abs.*, **11** [6], 357 (1932). E.P.R.

Splinterless glass. KURT ROOS. *Brit. Plastics & Molded Prod. Trader*, **4** [39], 136–37; [40], 191–92 (1932).—R. reviews some British, French, and Austrian patents dealing with splinterless glass which are distinguished from each other by (1) varying selection of substances for the intermediate layer, (2) selection of different adhesives, (3) application of varying working conditions (only pressure or pressure combined with heat), and (4) varying finish of the glass. Methods used for testing splinterless glass include (1) safety from splintering, (2) resistance to light, (3) to temperature, (4) water, (5) transparency and clearance, and (6) tests for longevity. M.V.K.

Character, significance, and requirements for safety glass. II. C. H. ZEFER. *Glashütte*, **62** [47], 836–38 (1932).—A review of different German and foreign patents dealing with safety glass is given. For Part I see *Ceram. Abs.*, **12** [4], 149 (1933). M.V.K.

"Planimetric" or "repeating" mirrors: their manufacture and mounting. M. D. *Glaces et Verres*, **5** [27], 20–24 (1932).—When two mirrors facing each other reflect the object placed between them a great number of times, two conditions are necessary to obtain a clear effect without considerable deformation, (1) special mirrors called "planimetric" or "repeating," must be used, and (2) the faces of the mirrors have to be perfect and parallel. The tint of the mirror is important; if it is dark, the reflected objects become distorted after several reproductions. The mirrors should be thick. The glass should be polished perfectly to be able to silver it directly without later retouching. The testing of the mirrors for planeness and parallelism of their faces is described. M.V.K.

Metallic mirror backing. ANON. *Amer. Glass Rev.*, **52** [20], 19–20 (1933).—Hiram W. Edwards, associate professor at the Univ. of Calif., has prepared metallic mirror surfaces which show 94% reflection throughout the visible light, using aluminum and magnesium evaporated in a vacuum and deposited upon glass. E.P.R.

Mining sand for glasses. ANON. *Glaces et Verres*, **5** [29], 2–9 (1932).—Methods used for mining and transporting the white sand of the Nemours and Fontainbleau region for the manufacture of optical and crystal glassware are described. This sand is exported to the U. S. and Japan. M.V.K.

Apparatus for registering shocks. J. CHEVALEY. *Glaces et Verres*, **5** [25], 19–20 (1932).—C. describes a simple apparatus for registering shocks during the transportation of glassware. M.V.K.

Limiting domains of metallography. K. SCHRÖTER. *Z. Metallkunde*, **23**, 197–201 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 32 (1932).—The preparation of samples for the microscopical examination of materials used in the manufacture of tungsten filament lamps is described. Samples of glass are chemically coated with silver, electrolytically coppered, embedded in tin solder, and etched with hydrofluoric acid. The paper contains a large number of photomicrographs. F.G.H.

"Ultra-flux" clay blocks in record run of bottle tank. ANON. *Amer. Glass Rev.*, **52** [22], 8 (1933).—The run was for 25 months and 17 days, making both clear flint and Coca-Cola green glass. E.P.R.

Use of tank furnaces for manufacturing glass electric bulbs. B. B. KHOVANSKI. *Keram. i Steklo*, **9** [1], 11–15 (1933).—K. describes experiments made in melting glass for electric bulbs in tank furnaces. The results were satisfactory, although the refractory lining of the tank was corroded more intensively. Data on the refractories used are given. M.V.K.

All-glass electric light bulbs for airways and parks. ANON. *Amer. Glass Rev.*, **52** [22], 11 (1933). E.P.R.

Industrial glass piping developed by Corning Glass Works. ANON. *Amer. Glass Rev.*, **52** [20], 9–10 (1933). E.P.R.

Research by Corning Glass Works on glass statuary. ANON. *Amer. Glass Rev.*, **52** [21], 8 (1933).—The Architectural Division of Corning Glass Works has proved that glass statues of large size are practicable. E.P.R.

Well-diffused light among advantages of glass brick in experimental shop. ANON. *Amer. Glass Rev.*, **52** [20], 10 (1933). E.P.R.

Transmission of heat through glass. J. LE BRAZ. *Glaces et Verres*, **5** [29], 12–18 (1932).—L. discusses the transmission of heat by glasses and the application of this property for heating houses. M.V.K.

Design and form as applied to the manufacture of glassware. J. H. HOGAN. *Pottery Glass Rec.* [Eng.], **15** [2], 42–46 (1933); for abstract see *Ceram. Abs.*, **12** [5], 187 (1933). M.V.K.

Glass in the decorative scheme. M. L. ANDERSON. *Decorator*, **31** [1], 17–21 (1933); for abstract see *Ceram. Abs.*, **12** [3], 102 (1933). M.V.K.

Glass for decorations and for furniture. E. J. RUHLMANN. *Glaces et Verres*, **5** [27], 2–7 (1932).—Because of its varied properties, glass has unlimited possibilities of use in interior decoration and furniture. Illustrated. M.V.K.

Decorative glass wins new distinction. WALTER RENDELL STOREY. *Amer. Glass Rev.*, **52** [22], 9 (1933); for abstract see *Ceram. Abs.*, **12** [5], 178 (1933). E.P.R.

Design treatment of glass seen as important in new architecture. J. BURN HELME. *Amer. Glass Rev.*, **52** [21], 22 (1933).—The birth of a new streamlined architecture which incorporates simplicity, economy, and austerity as the prime essentials of design was described by H. before the 35th Annual Meeting of the American Ceramic Society in Pittsburgh on Feburary 14. In the field of natural lighting he advocated the design treatment of glass as a lighting surface. E.P.R.

Modern architects favor glass. MADELINE LOVE. *Amer. Glass Rev.*, **52** [20], 21 (1933). E.P.R.

Mosaic windows of pot metal glass to feature building at World's Fair. ANON. *Amer. Glass Rev.*, **52** [20], 22 (1933). E.P.R.

Relics of first American glass factory at Jamestown displayed. ANON. *Amer. Glass Rev.*, **52** [21], 9 (1933).—Fragments of wine bottles and panes of window glass, products of the oldest glass furnace in America, founded in 1608 at Captain John Smith's colony at Jamestown, Va., were placed on exhibition for the first time on February 15, at the 35th Annual Meeting of the American Ceramic Society in Pittsburgh by Walter J. Sparks, archeologist of Richmond, Va. E.P.R.

America's oldest glass factory. W. J. SPARKS. *Glass Ind.*, **14** [4], 47–48 (1933).—A brief historical description of Jamestown glass, the earliest known in this country, is given. E.J.V.

Glass: the first American industry. ANON. *Nat. Glass Budget*, **48** [44], 3 (1933); *Amer. Glass Rev.*, **52** [23], 9 (1933).—A radio address delivered by Alexander Silverman, February, 1933, is presented. E.P.R.

Belgian glass combine. ANON. *Times Eng. Supp.*, **31**, 362 (1933).—Libbey-Owens has combined with Soc. Belge Glaces et Verres ("Glaver"), and a production agreement has been made with the Union des Verreries Mécaniques Belges and with Czechoslovakian plants. The Floreffe works is closed and polished plate glass will be made only at Moustier-sur-Sambre. H.H.S.

Application of statistical methods to quality control of manufactured products. B. P. DUDDING. Presented at the Feb., 1933, meeting of the Soc. Glass Tech.; abstracted in *Pottery Gaz.*, **58** [669], 349 (1933). E.J.V.

BOOKS

Glass and Glass Manufacture. PERCIVAL MARSON. Revised and enlarged by L. M. ANGUS-BUTTERWORTH. Isaac Pitman & Sons, London. 3s net. Reviewed in *Pottery Glass Rec.* [Eng.], **15** [3], 88 (1933).—Several new chapters dealing with the latest improvements in glass technology have been added to this interesting and useful book. M.V.K.

Textbook of Glassblowing. (Lehrbuch des Glasbläserei.) CARL WOITECEK. 2nd ed. Julius Springer, Vienna. 22.50 Rm. Reviewed in *Glashütte*, **63** [1], 15 (1933).—The book treats of all the latest devices, apparatus, and methods of operation used in glassblowing. M.V.K.

Glass Manufacture. M. A. BESBORODOV AND M. F. SHUR. *Keram. i Steklo*, **8** [10], 43–44 (1932); for review see *Ceram. Abs.*, **12** [4], 150 (1933). M.V.K.

PATENTS

Apparatus for cutting glass tubing. ERNEST ASHFORD. U. S. 1,900,971, March 14, 1933.

Apparatus for handling glass sheets. R. J. LOUVIAUX (Libbey-Owens-Ford Glass Co.). U. S. 1,901,463, March 14, 1933.

Edging apparatus. H. J. HAMANN (Libbey-Owens-Ford Glass Co.). U. S. 1,901,510, March 14, 1933.

Coupler for glass supporting tables. LE ROY L. HANDY (Libbey-Owens-Ford Glass Co.). U. S. 1,901,511, March 14, 1933.

Method for making laminated glass. A. G. WORRALL (Safetee Glass Co.). U. S. 1,901,574, March 14, 1933.

Manufacture of wired glass. A. L. FORSTER (Chance Bros. & Co., Ltd.). U. S. 1,901,743, March 14, 1933.

Glass drawing apparatus. H. F. CLARK (American Window Glass Co.). U. S. 1,901,896, March 21, 1933.

Manufacture of hollow glassware. G. E. ROWE (Hartford-Empire Co.). U. S. 1,902,140 to 1,902,142, March 21, 1933.

Apparatus for annealing glassware. P. L. GEER (Amsler-Morton Co.). U. S. 1,902,326, March 21, 1933.

Glass-feeding apparatus and method. K. E. PEILER (Hartford-Empire Co.). U. S. 1,902,788, March 21, 1933.

Means for circulating glass in gathering basins. A. F. MCNISH (John Moncrieff, Ltd.). U. S. 1,903,223, March 28, 1933.

Leer. S. B. BOWMAN (Hazel-Atlas Glass Co.). U. S. 1,903,281 and 1,903,282, April 4, 1933.

Metal-protected mirrors. S. C. LANGDON. Brit. 361,409, Aug. 20, 1930. (*C.A.*)

Heat-absorbing glasses. JENAER GLASWERK SCHOTT & GEN. Brit. 387,778, Feb. 22, 1933.

Continuous process for grinding and/or polishing glass plates, etc. F. ECKERT. Brit. 387,885, Feb. 22, 1933.

Optical glasses. JENAER GLASWERK SCHOTT & GEN. Brit. 388,118, March 1, 1933.

Leaded glasswork for windows, etc. A. R. POOLEY, A. G. HAYLER, AND H. W. PARKER & CO., LTD. Brit. 388,228, March 1, 1933.

Production of compound glass. A. KÄMPFER AND A. C. PLÖTZE. Brit. 388,287, March 1, 1933.

Glass-pouring processes for casting plate glass and glass plates. SOC. ANON. COMPAGNIE DE FLOREFFE. Brit. 388,653, March 8, 1933.

Manufacture of glass articles. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 388,716, March 8, 1933.

Strengthened or safety glass. TRIPLEX SAFETY GLASS CO., LTD., AND J. WILSON. Brit. 389,106, March 22, 1933. TRIPLEX SAFETY GLASS CO., LTD., L. V. D. SCORAH, AND J. WILSON. Brit. 389,115 and 389,151, March 22, 1933.

Glass or other tableware, etc., fitted with lids or covers. CHANCE BROS. & CO., LTD., AND S. J. COLLYER. Brit. 389,201, March 22, 1933.

Apparatus for hardening glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Brit. 389,314, March 22, 1933.

Applying fusible coloring substances to hot glass. JULIUS LACKNER. Austrian 130,615, June 15, 1932. Manipulative features are described. (*C.A.*)

Continuous heating and cooling furnace for glass. F. BINON. Belg. 387,734, May 31, 1932. Structural features. (*C.A.*)

Safety glass. MIROITERIE "LE LION," SOC. ANON. Belg. 387,943, May 31, 1932. A sheet of celluloid is interposed between two sheets of glass and the assembly is immersed in a chemical bath and subjected to high pressure and temperature. (*C.A.*)

Nonshatterable glass. C. M. I. WINTER. Belg. 388,148, May 31, 1932. Glass is rendered nonshatterable by applying a sheet of cellulose acetate in a bath containing a fatty solvent of high boiling point. (*C.A.*)

Safety glass. LOUIS C. F. PECHIN. Fr. 40,684, Aug. 20, 1931. More than 3 sheets of glass are joined together by a synthetic balsam having an n near that of glass. Fluorescein or halogenated fluoresceins are incorporated with the balsam to intercept the chemically active rays. Addition to 721,095, *Ceram. Abs.*, **11** [11], 566 (1932). (*C.A.*)

Safety glass. I. G. FARBENIND. A.-G. Fr. 734,688, April 6, 1932. The intermediate or adhesive layer is composed of hydrogenated natural rubber or products resulting from the hydrogenation of polymerized butadiene hydrocarbons. (*C.A.*)

Apparatus for making sheets of glass. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Fr. 735,017, April 12, 1932. (*C.A.*)

Glass furnace. CH. ROYER & SES ENFANTS (S. A. R. L.). Fr. 735,747, July 25, 1931. (*C.A.*)

Safety glass. SOCIETÀ ANONIMA V. I. S. (VETRO ITALIANO DI SICUREZZA). Fr. 736,028, April 27, 1932. A safety glass resistant to pressure and shock is composed of a plate of tempered glass covered on each face by a sheet of ordinary thin glass with the interposition of plates of celluloid, etc., the various plates being assembled by known processes. (*C.A.*)

Sheets of glass. FORGES ET ATELIERS DE CONSTRUCTIONS ÉLECTRIQUES DE JEUMONT. Fr. 736,368, Aug. 26, 1931. Means are described for pouring the molten glass. (*C.A.*)

Apparatus for air-tempering glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Fr. 736,421, Sept. 2, 1931. (*C.A.*)

Apparatus for annealing sheets of glass. FORGES ET ATELIERS DE CONSTRUCTIONS ÉLECTRIQUES DE JEUMONT. Fr. 736,726, Sept. 4, 1931. (*C.A.*)

Transparent sheets for making safety glass. FRIEDRICH MEYER. Fr. 737,042, May 13, 1932. Sheets for use alone or in making safety glass are made by mixing or dissolving hard substances such as celluloid, acetylcellulose, viscose, gelatin, or hardened resin in a solvent of high boiling point with soft or viscous substances such as rubber, soft resins or balsams, artificial gum-lac, or vinyl acetate. As solvents butyl stearate, dibutyl phthalate, tricresol phosphate, glycol, glycerol, and castor oil may be used. (*C.A.*)

Apparatus for rolling plate glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Ger. 560,252, Aug. 15, 1930. (*C.A.*)

Securing glass to cement or gypsum. KIKUJIRO MORITA. Ger. 560,320, June 13, 1931. Glass is coated on one side with a mixture of Na silicate and a metal oxide, *e.g.*, ZnO, which readily forms a silicate. The glass is then heated gradually to 100°, preferably by heating it to 40°, maintaining that temperature for a few hours, raising the temperature to 100°, and maintaining that temperature for 1 to 2 hr. The solid coating thus obtained does not corrode the glass and adheres well to cement or gypsum. (*C.A.*)

Cooling hollow glassware. A.-G. GLASHÜTTENWERKE ADLERHÜTTEN. Ger. 560,488, Oct. 1, 1929. Indirect cooling is followed directly by a short treatment with hot air. The tendency of the glass to lose alkali by solution is thus checked. The treatment is intended particularly for medicine bottles. (*C.A.*)

Imparting a dull surface to glassware. GUSTAV GANZ & CO. Ger. 560,489, Aug. 25, 1929. Electric light bulbs, etc., to which a dull inner surface has been imparted by known physical or chemical means, are after-treated with HF of 30 to 35% concentration. (*C.A.*)

Apparatus for making plate glass. YVON BRANCART. Ger. 561,212, Feb. 25, 1931. (*C.A.*)

Glass for magnesium-vapor lamps. MARTIN REGER AND GEORG GAIDIES (Patent-Treuhand-Ges. für elek. Glühlampen m. b. H.). Ger. 561,611, Jan. 18, 1931. An alkali-proof glass for Mg-vapor lamps is made by adding B_2O_3 to the usual mixture of alkali, alkaline earth, Al_2O_3, and SiO_2. The amount of SiO_2 is less than 50%. (*C.A.*)

Drawing tubes or rods of glass. PANCRAS SCHOONENBERG (N. V. Philips' Gloeilampenfabrieken). Ger. 561,650, Aug. 26, 1926. (*C.A.*)

Safety glass. DEUTSCHE OELFABRIK GRANDEL & CO. Ger. 563,046, June 26, 1931. Nonsplintering glass is prepared by uniting two or more glass sheets by means of an intermediate layer or layers of factice. Suitably, a liquid mixture of a fatty oil and S_2Cl_2, with or without resins, pigments, etc., is spread on the surface of a glass sheet. A second sheet is then superimposed and pressure is applied until the factice-forming reaction is complete. (*C.A.*)

Apparatus for rolling glass. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 563,418, Sept. 27, 1931. (*C.A.*)

Apparatus for rolling glass. CHARLES KIRCHHEIM. Ger. 563,419, July 7, 1931. (*C.A.*)

Glass-annealing leer. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 563,496, May 14, 1931. (*C.A.*)

Device for producing glass fibers. O. OSWALD & CO. Ger. 563,612, May 28, 1930. (*C.A.*)

Canal annealing furnace for glass. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 563,855, April 8, 1931. (*C.A.*)

Glass. JENAER GLASWERK SCHOTT & GEN. Ger. 564,244, Nov. 14, 1930. Glass is manufactured under reducing conditions by adding to the mix or to the molten glass a

phosphide, *e.g.*, Fe_3P, or other compound containing P in a lower stage of oxidation, *e.g.*, $Ca(H_2PO_2)_2$. (*C.A.*)

Method of cooling nonsplintering glass with water and air. ROBERT DELLOYE. Ger. 564,463, May 13, 1930. (*C.A.*)

Hardening glass panes. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Ger. 564,701, Oct. 8, 1931. (*C.A.*)

Frosting glass. ELISABETH HONIGMANN (Patent-Treuhand-Ges. für elek. Glühlampen m. b. H.). Ger. 564,702, Nov. 11, 1931. Glass is frosted by an etching bath of NH_4F and HF saturated or nearly saturated with $(NH_4)_2SiO_4$. The viscosity of the bath can be diminished by addition of $BaSO_4$. (*C.A.*)

Continuous apparatus for making glass tubes or rods. LEOPOLD RIEDEL. Ger. 565,239, March 22, 1928. (*C.A.*)

Method of joining metal to glass by fusion. OSIAS KRUH. Ger. 566,054, May 9, 1931. (*C.A.*)

Barium glass for electric insulation. KÔZÔ TAPATA AND KENSUKE EGAMI (Minister of Communications). Jap. 93,969, Dec. 18, 1931. The glass contains K_2O 0.2–0.9, Na_2O 0.1–0.8, BaO 1.5–3.0, and SiO_2 5.0–10.0 mol. (*C.A.*)

Refractory glass. MASAHIDE KAMIYAMA (K. K. Simazu Seisakuzyo). Jap. 94,042, Dec. 26, 1931. The glass is made of SiO_2 65–75, B_2O_3 10–15, Al_2O_3 2–5, alkali oxide 4–10, and ZnO 3–10%. The linear expansion coefficient is 4×10^{-6}. It is resistant to acids and alkalis. (*C.A.*)

Replaceable floating abutment bodies for the floaters in glass furnaces. FIN MAGNE. Norw. 49,555, Nov. 2, 1931. (*C.A.*)

Structural Clay Products

Properties of porous building materials. I. Absolute porosity and saturation coefficient. E. MADGWICK. *Phil. Mag.*, **12,** 1155 (1931).—Knowledge as to the porosity of building material is important because of the action of absorbed water and gases causing solution of the material and the inducement of large stresses in freezing. Porosity is defined as the amount of absorbed water per cubic centimeter. The total pore space as determined by air volume of the pores is called the absolute porosity. The porosity divided by the absolute porosity is called the saturation coefficient. Measurements of several materials are given. **II. Flow of air through porous bodies.** *Ibid.*, **12,** 1160 (1931).—The permeability of a porous material to a gas is defined as the rate of flow per square centimeter through unit thickness under the action of unit pressure difference. The reciprocal of the permeability is called the resistivity of the material. Data on limestones, sandstone brick, and plasters are given. The problem of materials in layers is also studied and a formula for computing such a flow is derived and experimentally verified. **III. Theory of absorption and transmission of water by porous bodies.** *Ibid.*, **13,** 632 (1932).—The flow of water under controlled conditions is studied and an equation is derived which expresses this flow in terms of measurable physical constants. The cases of flow in different directions as to gravity are treated and the equations are modified so as to apply to these various sets of conditions. **IV. Determination of absorption constants of a homogeneous specimen.** *Ibid.*, **13,** 641 (1932).—The time course of the absorption of water by a porous material is measured by means of a capillary tube water supply and by noting the rate of flow of water from the tube. From the time curve of absorption the total quantity of water absorbed in any given time can be estimated. The resistivity penetration constant and porosity under various water pressures are determined for a series of different materials. There was considerable variation in different specimens of the same material, which fact is postulated as explaining the variation in weathering rate of the same material. **V. Absorption of water in some special cases.** *Ibid.*, **14,** 180 (1932).—A method for determining the absorption constant of any number of layers of different materials is derived. One particular case is that of a porous body covered with a thin coat as a protection. Results of studies of such combinations are cited. **VI. Autographic apparatus for measuring rates of flow of water.** *Ibid.*, **14,** 486 (1932).—The rate of flow of water through a porous body is proportional to the fall in pressure through the body. This principle is utilized to measure the rate of flow by recording this pressure difference on a rotating drum. **VII. Problem of damp walls.** *Ibid.*, **14,** 491 (1932).—Water flows into porous walls from the outside inward and from the bottom upward. Wind pressure tends to force moisture inward. Computations show that water may penetrate a certain brick wall 9 in. thick in 3 hr. and when this same wall is covered with a cement layer it

will take about 16 days to wet through. The conditions necessary for the deposition of water by condensation from the water-saturated air penetrating a wall from a warmer zone to a zone below the dew point are discussed. To prevent water drops forming, the material must absorb such water faster than the condensation rate. Equipment satisfactory for making tests of this property is described. J.T.L.

Standardizing paving brick. ANON. *Brit. Clayworker*, **41** [491], 396 (1933).—Information is given concerning German paving brick and its standardization. This information covers size and shape, nonslip surface, porosity and water absorption, resistance to frost, strength, impact, abrasion, and the rattler test. R.A.H.

Lightweight sand-lime brick. ANON. *Tonind.-Ztg.*, **57** [22], 260–62 (1933).—Sand-lime brick with grooves and many holes are being manufactured. Porous sand-lime brick are not being used on a large scale. The use of mixtures of lime and kieselguhr has been proposed. W.M.C.

Hardening process of sand-lime brick. W. DAWIHL. *Tonind.-Ztg.*, **57** [22], 266 (1933).—The most important process is the formation of a gel at high temperatures which will cement the brick components so that they can resist the influence of water. W.M.C.

Mineral powder for use in sand-lime brick. B. KRIEGER. *Tonind.-Ztg.*, **57** [22], 263–64 (1933). W.M.C.

Sand-lime brick in Bavaria. E. SCHLEIER. *Tonind.-Ztg.*, **57** [22], 259–60 (1933).—In recent years, sand-lime brick have been used for face brick. Some buildings exhibit colored sand-lime brick. Illustrated. W.M.C.

Standard specifications for sand-lime brick in Jugoslavia. ANON. *Tonind.-Ztg.*, **57** [13], 152 (1933).—The new specifications stipulate that the minimum strength of dry brick should be 120 kg./cm.^{2}; the size should be 25 x 12 x 6.5 cm., with deviations of not more than 0.2 cm.; dry brick should absorb not less than 10% water. The freezing behavior is tested by freezing the brick 25 times at −4°C and reheating them to 20°C; the duration of the test is 4 hr. W.M.C.

Sand as a source of defects in brick manufacture. N. O. *Ziegelwelt* (*Deut. Töpfer Ziegler-Ztg.*), **64** [5], 48 (1933).—O. emphasizes the necessity of testing sand for its suitability for manufacturing brick, with illustrations of cases from practice. M.V.K.

Hard-fired brick for road construction. A. HIELSCHER. *Tonind.-Ztg.*, **57** [19], 219–21; [22], 264–66 (1933).—Properties of paving materials for roads are outlined. Different types of paving are described. The brick may be laid in lime or cement mortar, according to the type of traffic. Construction principles of German, American, and Dutch highways are compared. Illustrated. See also *Ceram. Abs.*, **12** [1], 17 (1933). W.M.C.

Testing hard-fired brick for road construction. ANON. *Tonind.-Ztg.*, **57** [19], 223–24 (1933).—The tests include investigations on porosity, toughness, strength, weathering behavior, wear, and bending strength of the brick. W.M.C.

Dearborn sewer system of reinforced brick masonry. CHARLES H. FORK. *Clay-Worker*, **99** [3], 100–101 (1933).—Full details of sewer design and construction of the reinforced brick masonry combined storm and sanitary drain in Dearborn, Mich., are given. Illustrated. E.J.V.

Small brick houses. A. LEE. *Tonind.-Ztg.*, **57** [20], 234–39 (1933).—The construction of small brick houses has been increasing in Germany. The advantages of using a new type of hollow tile are outlined. Illustrations show the construction of the walls and the roof of a brick house in seven days. See also *Ceram. Abs.*, **11** [12], 615 (1932). W.M.C.

Use of brick in the experimental settlement, Berlin-Haselhorst, Germany. ANON. *Tonind.-Ztg.*, **57** [10], 111–12 (1933).—In this settlement different types of building materials have been used. The difficulties and faults encountered are shown. The best results are obtained from buildings using common brick. W.M.C.

Factory-made house. ANON. *Brick Clay Rec.*, **82** [3], 100–104 (1933).—The fabricated house still remains a dream and clay products have the best opportunity to dominate the home building field. A review of comments on the low-priced factory-made home is given. Illustrated. E.J.V.

Structural clay tile problems. HENRY GIESE. *Clay-Worker*, **99** [3], 108–109 (1933).—G. discusses the problems of selling, building, and design as encountered in the use of structural clay tile in the construction of farm buildings of the most modern type. E.J.V.

Church architecture. ANON. *Brick Clay Rec.*, **82** [3], 90–91 (1933).—An all-brick edifice in which practically every item of ornamentation and exterior construction is made of brick clay, with extensive use of hand-molded brick, has been erected in Au-

burn, R. I. The Tuttle Brick Co., Middletown, Conn., supplied 130,000 face brick and several thousand hand-molded brick as well as many old style terra cotta moldings. Construction details are given. Illustrated. E.J.V.

Profits in brickmaking. F. W. GLECKLER. *Clay-Worker*, **99** [3], 97 (1933).—G. traces the progress made in brickmaking in the past forty years, and shows how improved common brick can be made at a lower cost. E.J.V.

Use of diatomites in construction and in filtration. VICTOR CHARRIN. *Génie civil*, **101**, 111–13 (1932).—Brick of pure diatomite would require heating to a temperature that would change the physical properties. A light and porous brick can be made by adding 8 to 10% fire clay and 1 to 2% lime and heating to 1050°. Special mortars should be used with these brick, preferably a mixture of 80% diatomite with 20% Portland cement with a minimum of water. As a filter it is ideal but should not be heated above 870°. See also *Ceram. Abs.*, **12** [2], 78 (1933). (*C.A.*)

Electric hydraulic sewer-pipe press. ROBERT C. ZEHM. Presented at American Ceramic Society meeting, Feb., 1933; abstracted in *Clay-Worker*, **99** [3], 101 (1933). E.J.V.

High-pressure hydraulic brick press. ROBERT C. ZEHM AND BENJAMIN F. LASSMAN. Presented at Amer. Ceram. Soc. meeting, Feb., 1933; abstracted in *Clay-Worker*, **99** [3], 101 (1933). E.J.V.

Brickmaking in ancient and modern times. RUD. WITTE. *Clay-Worker*, **99** [3], 104–105 (1933).—The Egyptians, Babylonians, and Assyrians were, to all accounts, the first brickmakers in the history of our world. W. traces the development of brickmaking and the transfer of the knowledge through the ages to the present day, giving many historical facts. E.J.V.

Manufacture of brick in antiquity. MARTIN HUEBEL. *Ziegelwelt* (*Deut. Töpfer Ziegler-Ztg.*), pp. 51–52 (1931); *Chem. Zentr.* No. 1, p. 2014 (1931).—In Babylon a fire temperature of 500 to 600° was used, and the brick could be cut with a knife after firing. The brick were mortared with bitumen. The Romans dried brick for many years; light brick were also known. To increase the tenacity they used straw. The glaze was applied after the brick were placed in permanent positions. J.G.T.

Color in ceramics. Methods in the brick and tile trades. W. L. FABIANIC. *Foote-Prints on Chemicals, Metals, Alloys, and Ores*, December, 1932; abstracted in *Chem. Trade Jour.*, **92** [2390], 197–98 (1933); for abstract see *Ceram. Abs.*, **11** [11], 569 (1932). M.V.K.

PATENTS

Tile manufacture. WILLIAM SALISBURY. U. S. 1,901,195, March 14, 1933.

Porous clay products. AAGE NIELSEN. Fr. 735,954, April 26, 1932. The clay mass, before being made porous in known manner, is rendered liquid by the addition of alkali hydroxides or salts of alkaline products and weak acids. The mass after being made porous is brought to a consistency suitable for molding by the addition of chemical products such as NaCl, Na_2SO_4, $CaSO_4$, $CaCl_2$, or $MgCl_2$, or by chemical transformations. (*C.A.*)

Refractories

Sintered corundum. OTTO BÄR. *Feuerungstechnik*, **20** [11], 174–75 (1932).—Sintered corundum is obtained from chemically pure alumina. During fine grinding some acid must be added because alumina powder forms a positive suspensoid in a watery suspension in contrast to clays and kaolins forming negative. It is shaped either in gypsum molds or by pressing. The firing takes place in electric furnaces or in gas furnaces fired to 1800°C. Owing to a crystallization process of alumina particles in a solid state, the particles grow together in the α-modification and form a dense structure similar to granite. Chemically, sintered corundum consists of 99.3 to 99.8% Al_2O_3. It is resistant to a 6-hr. boiling with 10 or 30% solution of caustic soda and to superheated water steam. It is stable to fusions of Na_2O, NaOH, Na_2CO_3, metallic aluminum, manganese iron, and other metallic alloys, to evaporation to dryness, and to glass and slag melts. It resists blast-furnace slag, lead carbonate, lead, and other metal silicates, lead boron glasses, glaze frits, and all silicate glasses. Its specific gravity is 3.9, hardness, 9 (Mohs'), and porosity, 0. Pyrometer tubes are gas tight when heated up to 1720°C and under an inner pressure of 776 mm. The thermal expansion between 20 and 800° is 80.10^{-10}. Sintered corundum is also highly resistant to sudden changes of temperature. It contains a resistance to pressure of 5140 kg./sq. cm. and a tensile strength

of 350 kg./sq. cm. The softening point lies near 1730°. The deformation point could not be determined. Sintered corundum may be used for chemical vessels, pyrometer tubes, and as highly refractory material for small furnaces and laboratory vessels, etc. M.V.K.

Sintered corundum. RENÉ LEONHARDT. *Ind. Silicati*, **11** [1], 10–11 (1933).—The manufacture, properties, and uses of sintered corundum products are detailed. M.V.K.

Sinterkorund. ANON. *Ind. Chemist*, **8** [4], 150–52 (1932); abstracted in *Metals & Alloys*, **4** [2], 55 (1933).—Tables of data such as thermal conductivity, thermal expansion, electrical resistance, etc., are given. Many applications are cited. Five references are included. See preceding abstracts and *Ceram. Abs.*, **12** [1], 18; [3], 110; [4], 156 (1933). E.P.R.

Conductivity of corundum. H. v. WARTENBERG AND E. PROPHET. *Z. Elektrochem.*, **38**, 849–50 (1932).—The conductivities of corundum, in the form of a small plate cut perpendicular to the mechanical axis, are 1.3×10^{-7}, 5.0×10^{-7}, 2.0×10^{-6}, and 5.0×10^{-6} at 1500, 1600, 1700, and 1800° absolute, respectively. The graph of log conductivity *vs.* $1/T$ shows the results to be lower than those found by Podzus for pressed Al_2O_3 powder, which is in agreement with the theory of v. Hevesy that a powder is a better conductor than a single crystal. (*C.A.*)

Refractories. HIGGINGS. Toronto Univ. *Bull.*, pp. 159–80 (1932); abstracted in *Refrac. Jour.*, **9** [2], 88 (1933).—H. found that the present Canadian electrical porcelain refractories are considerably improved by increasing the magnesia and alumina contents. E.P.R.

Characteristics of some refractory products. III. MARCEL LÉPINGLE. *Rev. mat. constr. trav. pub.*, No. 281, pp. 29–31*B* (1933).—Data on refractory products of Czechoslovakia, U. S. A., Sweden, and Spain are given. For Part II see *Ceram. Abs.*, **12** [5], 193 (1933). M.V.K.

Limits of refractoriness. ANON. *Tonind.-Ztg.*, **57** [13], 149–50 (1933).—A number of refractory products will melt at temperatures of more than 2000°C. They include chromite brick, magnesite products, sintered alumina, and Siemensit. Oxides of Be, Ca, Zr, Hf, Mg, and Th will melt at temperatures between 2570 and 3050°. The highest melting point yet discovered is 4215°, obtained by mixing 4 parts of tantalum carbide and 1 part of hafnium carbide. W.M.C.

Refractories. VI. Methods of determining water absorption. MINORU NAKAMOTO. *Jour. Soc. Chem. Ind.* [Japan], **35** [5], 214*B* (1932).—Different refractories were subjected to drying and water absorption tests. The results showed that (1) drying at 130, 110, or 100°C yields the same results, and (2) partial or complete immersion in water produces the same results. For Parts IV and V see *Ceram. Abs.*, **11** [12], 617 (1932). M.V.K.

Monolithic refractory concretes. H. T. COSS AND N. J. KENT. *Ceram. Age*, **20** [6], 212–14 (1932).—The development of hydraulic refractory concrete followed closely the development and extension in the use of aluminous cements. The growth of the domestic oil burner business provided the impetus for the development of refractory concretes. Portland cement is not generally used in refractory concrete because of the fluxing action with fireclay aggregate. The most widely used material is high alumina cement which has the following analysis: SiO_2 3.5, $Al_2O_3 + TiO_2$ 45.0, FeO 10.0, Fe_2O_3 6.5, CaO 33.5, MgO 0.5, Mn_2O_3 0.15, and $SO_3 + S$ 0.15. This material when used with fireclay grog has a wide range of vitrification prior to the softening of the mass. One commercial concrete has a softening point of cones 28 to 30, depending upon particle size. The crushing strength of this material at 2700°F is 9500 lb./sq. in. and the shrinkage at that temperature is 1.7%. The concrete is mixed with 20% water for pouring consistency and 16% water for ramming or tamping. Metal or wooden forms are used for holding the concrete and these can be removed in approximately 8 hr. Heat can be applied after 12 to 48 hr. of air curing, the time being dependent on the size of the installation. This type of concrete is finding extensive use in oil-burner installations and in industry for lining inspection doors in boiler plants, in door-frame linings in coke plants and in making small arches, special shapes, etc. R.G.M.

Refractory cements and lutes. W. O. LAKE. *Sands, Clays, & Minerals*, **1** [3], 56–58 (1933).—Refractory cements of good quality should possess (1) high refractory quality, (2) low shrinkage, (3) coefficient of expansion and contraction equal to the brick with which they are to be used, (4) resistance to load under high temperature, (5) capability of resisting slag attack, and (6) smooth working quality. M.V.K.

Refractory materials in casting practice. N. N. RUBTZOV. *Liteinoe delo*, No. 11–12, pp. 5–12 (1930); abstracted in *Jour. Inst. Metals*, **50** [4], 273 (1932).—Refractory

materials for casting furnaces are classified as follows: (1) acid-Dinas brick, (2) basic-chamotte, magnesia, bauxite, (3) semi-acid quartz chamotte, (4) neutral-chrome, zircon, and (5) carbonaceous carbon and silicon carbide. Properties of refractories analyzed are resistance to wear, heat capacity, conductivity, constancy of volume, and resistance to sharp changes of temperature, slagging, and chemical corrosion. F.G.H.

Chamotte refractory materials. B. P. SELIVANOV. *Liteinoe delo*, No. 2, pp. 5–8 (1931); abstracted in *Jour. Inst. Metals*, **50** [4], 274 (1932).—A preliminary estimate of the qualities of chamotte refractories can be made from the color, large grain size (1 to $1^1/_2$ mm.), resistance to scratching (must not crumble), absence of cracks, behavior under load at high temperatures (with 1 kg./sq. cm. the softening point must be at least 1300°C), and determination of density (2.5 actual). To obtain a good chamotte the material is fired at 900°C, ground to 1.5 mm., made into a paste with 45% clay content, molded at maximum pressure, dried at 100°C, and fired at 1300°C. F.G.H.

Studies of refractory minerals, "Silax." ANON. *Refrac. Jour.*, **9** [2], 84 (1933).—"Silax" is a cream colored coarse soft sandstone, the analysis of which is similar to that of the Derbyshire ganister sands containing about 8% alumina. E.P.R.

"Carborundum" as a refractory for melting standard gold alloy. C. R. ROESON. *Ann. Rept. Royal Mint* [London], **60**, 132 (1929); abstracted in *Jour. Inst. Metals*, **50** [3], 199 (1932).—Pots for melting standard gold in an electric furnace were lined with silicon carbide and 10% clay. After many melts the alloy was found to have penetrated into the lining and the metal recovered was a purplish gray color and very brittle after remelting. It was found to contain 0.14% silicon. It appears that 0.04% silicon in standard gold renders it unfit for rolling. The mechanism by which the silicon is introduced into the alloy in the furnace is discussed. F.G.H.

Employment of acid-proof and refractory materials. JOHAN PALM. *Tek. Tid. Uppl. C, Kemi*, **62**, 73–76, 86–88, 92–94 (1932).—The physical and mechanical properties and acid and alkali resistance of various types of ceramic products from porcelain to brick tile are reviewed. (*C.A.*)

Influence of carbon on the transformation of silica in Dinas brick. W. N. SCHVETZOV. *Uralskiy Tehnik*, No. 5–6, pp. 36–39 (1930); abstracted in *Jour. Inst. Metals*, **50** [4], 274 (1932).—Magnesia and alumina in Dinas brick hinder the transformation of amorphous silica into well-defined crystalline tridymite. Lime apparently assists the formation of cristobalite. All modifications of carbon favor crystalline transformation of quartz into tridymite at the temperature of brick kilns, and into cristobalite at the temperature of the Martin furnace. F.G.H.

Disintegration of fireclay products by carbon monoxide. A. T. GREEN, W. HUGILL, AND H. ELLERTON. *Bull. Brit. Refrac. Research Assn.*, No. 27, pp. 39–44 (March, 1932). (*J.I.S.I.*)

Action of carbon monoxide on refractory materials. III. Experiments (*a*) with laboratory-prepared specimens, (*b*) on the influence of reheating disintegrable products. W. HUGILL, H. ELLERTON, AND A. T. GREEN. Inst. of Gas Engrs., *Copyright Pub.*, No. 61, pp. 42–46 (1932); *Bull. Brit. Refrac. Research Assn.*, No. 28, pp. 64–69 (Aug., 1932).—The order of potency of 4 ferruginous additions causing disintegration is (1) hematite (greatest), (2) magnetite, (3) pyrite, and (4) Fe oxide-clay fusion. The average effect of increasing the temperature of firing is to increase the resistance to disintegration. Increasing the temperature of soaking reduced disintegration. For Parts I and II see *Ceram. Abs.*, **11** [9], 493 (1932). (*C.A.*)

Silicon carbide brick. GZ. *Feuerungstechnik*, **21** [1], 14 (1953).—The "Sicto-brick," manufactured by A.-B. Höganäs, Sweden, contains about 85% SiC. It shows a high volume stability, small thermal expansion, low porosity, and high resistance to pressure, besides being resistant to the chemical attack of flames and slag. After 10,000 to 15,000 operating hours, silicon carbide brick showed no considerable injury. These brick can not be used for ashes with a high alkali and lime content and with a low silica content. M.V.K.

Silica lining for firing silica brick. G. OETZEL. *Tonind.-Ztg.*, **57** [21], 249–50 (1933).—This is a discussion of the paper by Bergau (*Ceram. Abs.*, **12** [3], 110 (1933)). Properties of different types of refractories are compared. Periodic kilns or groups of kilns should be used for firing silica brick. Refractories of high alumina content are preferred as a lining for these kilns. W.M.C.

Notes on silica brick and chrome products. W. J. REES AND T. R. LYNAM. *Bull. Brit. Refrac. Research Assn.*, No. 27, pp. 34–38 (March, 1932). (*J.I.S.I.*)

Experiments on chrome-silica brick. II. T. R. LYNAM AND W. J. REES. *Bull. Brit. Refrac. Research Assn.*, No. 28, pp. 28–40 (Aug., 1932). (*J.I.S.I.*)

Effect of oxides of iron and chromium and a reducing atmosphere on the rate of

tridymite formation in a silica brick batch. T. R. LYNAM AND W. J. REES. *Bull. Brit. Refrac. Research Assn.*, No. 28, pp. 41–48 (Aug., 1932). (*J.I.S.I.*)

Chromium. II. Use as refractory. ANON. *Ind. chimique*, **20** [229], 90–92 (1933).—It is important to know the proportions of iron, alumina, and silica present in the chromium mineral for the manufacture of refractories. The normal ratio of Cr_2O_3 to iron varies between 2:1 and 3:1; if the iron content is higher, the mineral is more fusible. Generally, the mineral used in the refractory industry contains 33 to 48% chromium sesquioxides, 12 to 24% alumina, 12 to 24% iron, 14 to 18% magnesia, and up to 10% silica. Greece, Cuba, and South Africa mine the best chromite for the refractory industry. Refractories with a chromite base melt between 1950 and 2050°. The density varies between 3.9 and 4. Chromite brick are highly resistant at relatively low temperatures but tend to become friable at 1450°. Because of their resistance to sulfurous gases, chromite brick render great service in furnaces used for drying paper pulp with sulfite. For Part I see *Ceram. Abs.*, **12** [5], 203 (1933). M.V.K.

Manufacture of slag-resisting magnesia and alumina products. H. SALMANG AND M. PLANZ. *Arch. Eisenhüttenwesen*, **6**, 341–45 (1933).—The most favorable conditions were determined for manufacturing products from magnesia, alumina, spinel, and mixtures of magnesia and alumina containing 45 and 2% magnesia, respectively. The best grain composition for magnesia is 20% fired magnesia of 0.20 to 0.06 mm., 70% fired magnesia smaller than 0.06 mm., and 10% nonfired magnesia smaller than 0.06 mm. The other substances gave best results with the following composition: 10% fired oxides of 0.2 to 0.06 mm. grain size, 80% fired oxides smaller than 0.06 mm., and 10% nonfired oxides smaller than 0.06 mm. Chlorides were used in preparing the oxide mixtures. No shrinkage should be encountered in 90% of the oxides after firing at 1500 to 1750°C. The amount of shrinkage during drying and firing should be determined exactly before starting large scale manufacturing. The behavior of nonporous crucibles of high refractoriness was tested by melting a basic manganese silicate, an open-hearth slag, and a basic (Thomas) slag. The attack on the crucibles was very small. More mechanical than chemical attacks were observed. The thermal expansion of all crucibles changes with the temperature linearly, and therefore the crucibles may be dropped into water from 1600°C without cracking. W.M.C.

Present-day applications of magnesite brick. ANON. *Brit. Clayworker*, **41** [491], 380–83 (1933).—Although the chief market is for steel furnaces, there are several lines where brick are increasingly used. Detailed discussions are given of magnesite linings for electric steel furnaces, electric blast furnaces, antimony and silver refining, lead smelting, copper metallurgy, and cement kilns. Magnesite linings in steel manufacture using the open-hearth or basic Bessemer systems in regenerators and mixers are briefly discussed. R.A.H.

Chemistry of a fire brick. J. F. HYSLOP. *Brit. Clayworker*, **41** [491], 397–402 (1933).—A discussion is presented with formulas of reactions occurring when firing clay into brick, and the action of flux on fire brick with relative reaction on silica, corundum, and mullite is described. H. concludes that the life of a brick is generally a fight between adaptability and inertness, *i.e.*, adaptability to changing environment, *e.g.*, rapid changes in temperature, and inertness to temperature, load, and fluxes. R.A.H.

Sillimanite, a refractory stable to lignite ash. E. LUX. *Feuerungstechnik*, **21** [1], 14 (1933).—Sillimanite brick behaved well in furnaces fired with lignite, especially saliferous lignite. M.V.K.

Treatment of graphite crucibles in melting practice. R. THEWS. *Metallbörse*, **21**, 1203–1204 (1931); abstracted in *Jour. Inst. Metals*, **50** [5], 331 (1932).—Practical hints are given for the preservation of graphite, (plumbago) crucibles used for melting nonferrous metals. F.G.H.

Design of oil-fired crucible furnaces. G. S. WATSON. *Foundry Trade Jour.*, **46** [809], 117–20 (1932); abstracted in *Mech. Eng.*, **54** [6], 453 (1932).—W. discusses the principles of oil-fired crucible furnace construction with particular regard to the burners, oil-blast inlet, combustion chamber, metal preheating chamber, and waste-products outlet. F.G.H.

Setting refractory brick in marine boiler furnaces. A. L. CURTIS. *Sands, Clays, & Minerals*, **1** [2], 12–19 (1932).—C. describes four methods used for setting refractories when lining high-temperature furnaces, (1) square fire brick cored laterally, (2) grooved fire brick, (3) rectangular or square fire brick cored longitudinally, and (4) the "Wildish" system. Experiments show that the bolt which fixes the brickwork should be protected from the naked flame; bolts should be equally rigid in heat and cold; the cavity in the brick should possess oblique faces in order to disperse the stresses more thoroughly; the brick should permit easy building up and dismantling. The only system which

fulfills these conditions in Great Britain is the "Wildish" system, which is also used for special firebrick plugs for charging holes of furnaces. M.V.K.

Selecting refractories for boiler furnaces. H. S. *Feuerungstechnik*, **21** [2], 29 (1933).—If the composition of the brick is right, the layer of slag forms a protective coat; if it is unsuitable, destruction is rapid. Coarse structure brick are best suited for the lateral parts of the masonry and fine structure brick for the other places. The firing temperature influences the longevity of the refractory lining. M.V.K.

Effect of flue dust on boiler linings. A. B. SEARLE. *Steam Eng.*, **1** [8], 340 (1932); abstracted in *Mech. Eng.*, **54** [9], 668 (1932).—Notes relating to the effects of flue dust upon boiler refractories are presented. Methods by which the destructive action of flue dust may be reduced are described. F.G.H.

Modern developments in furnace refractories. ANON. *World Power*, **17** [1], 58 (1932); abstracted in *Metals & Alloys*, **3** [12], 360 (1932). E.P.R.

Working of rotary pulverized fuel-fired melting furnaces. W. SCOTT AND S. E. DAWSON. *Foundry Trade Jour.*, **46** [824], 335–38 (1932); abstracted in *Mech. Eng.*, **54** [10], 725 (1932).—Refractory linings and the calculation of lining costs for rotary metal-melting furnaces are described. Illustrated. F.G.H.

Refractory recuperators for gas-fired metallurgical furnaces. L. BOVET. *Arts et Métiers*, **85**, 313–21 (Sept., 1932).—B. describes the construction of recuperators in which the waste gases and air to be heated are separated by specially shaped refractories (Radot system), and he studies the calculations involved in designing and determining the dimensions of a recuperator for any given case. (*J.I.S.I.*)

Uniformity in refractories manufacture. H. M. KRANER. *Steel*, **88** [1], 47 (1931); abstracted in *Metals & Alloys*, **3** [7], 225 (1932).—Minor developments in the refractory industry for 1930 include definite improvements in size and shape control of clay refractories and a greater degree of uniformity in quality and methods of manufacture. Satisfactory bonding materials have been achieved for use with zircon and magnesia furnace linings and superior patching materials have been developed from a study of the system, CaO–MgO–Fe_2O_3. E.P.R.

Talc as a refractory. MAMYKIN AND PERMIAKOV. *Uralskiy Tehnik*, **7** [1], 12–17 (1931); abstracted in *Jour. Inst. Metals*, **50** [4], 274 (1932).—The limit of refractoriness of talc is at 1640 to 1660°C in an oxidizing atmosphere and at 1480 to 1575°C in a reducing atmosphere. Contraction in volume at 1300°C is 5%. The specimens withstood 23 intermittent heatings at 850°C and quenchings in water. The hydroscopicity of fired talc varies between 2.6 and 15%. The compressive strength of raw talc is 186.7 kg./sq. cm. and that of fired talc is 1080 kg./sq. cm. Talc for brick in working furnaces gave good results. F.G.H.

Uses of refractory materials in the foundry. J. G. A. SKERL. *Refrac. Jour.*, **9** [2], 59–63 (1933).—Fire brick are more resistant to the action of iron oxide than are silica-rammed cupola linings. Softening points of iron silicates are as follows: $4FeO$, $1SiO_2$ at 1280°C; $3FeO$, $1SiO_2$ at 1220°C; $2FeO$, $1SiO_2$ at 1270°C; $3FeO$, $2SiO_2$ at 1140°C; $1FeO$, $1SiO_2$ at 1120°C. The results show that the high-alumina brick is more resistant to blast-furnace slag than that containing less alumina, but that the silica brick, as could be seen from figures, is even more resistant until the percentage of slag reaches the figure of 40%. See also *Ceram. Abs.*, **12** [4], 160 (1933). E.P.R.

Soda ash as a refining agent. N. L. EVANS. *Refrac. Jour.*, **9** [2], 74 (1933).—Sodium carbonate as a cupola flux makes contact with the lining at the slag level which is patched up every day. A surface glaze appears to be protective against further serious attack. Soda ash leaves a clean, smooth surface instead of allowing hard lumps of slag to adhere. In the case of receivers which are only infrequently relined, the trouble will not be serious if the brickwork joints are thin and the difficulty can be entirely overcome by the use of high-alumina brick. A graphite wash over the ganister daub also is helpful. See also *Ceram. Abs.*, **12** [5], 182 (1933). E.P.R.

Insulating materials and their utility. C. STANLEY READ. *Refrac. Jour.*, **9** [2], 69–71 (1933).—At 1600°F, $4^1/_2$-in. insulating brick could be used with the resultant external temperature of 220°F and a heat transmission of 370 B.t.u./sq. ft./hr. Joints should be thin and the brick well dampened before laying. Insulation is secured by applying a facing composition. E.P.R.

Physical properties of high-melting compounds. K. BECKER. *Physik. Z.*, **34** [5], 185–98 (1933).—Present knowledge of high-melting compounds formed by 4th, 5th, and 6th periodic group elements is reviewed. Carbides are produced by heating metal and carbon at 1400 to 2200°C, nitrides by heating the metals in nitrogen at 1100 to 1200°C, and borides by heating powdered metals and boron. The powders are pressed into buttons and sintered twice up to 3000°C in reducing or neutral atmospheres or in

vacuum. Carbides, nitrides, and borides may also be obtained by heating metal wires in an atmosphere containing hydrocarbons, nitrogen or ammonia, and boron bromide vapors. Data on structure, density, hardness, strength, melting point, rate of evaporation, thermal expansion, electric conductivity, super-conductivity, electron emission, and magnetic and optical properties are presented. See also article by Agte, *Ceram. Abs.*, **12** [5], 192 (1933). W.M.C.

Steel works demands in refractories. ANON. Presented at a joint meeting of the Sheffield Soc. of Engineers and Metallurgists and the Refractories Assn. of Great Britain, Dec., 1932; abstracted in *Refrac. Jour.*, **9** [2], 47–54 (1933). E.P.R.

Bauxite. F. A. W. LIVERMORE. *Metal Ind.* [London], **42** [12], 321–22 (1933). M.V.K.

Bauxite deposits of Poshan and Tzechuan Districts, Shantung. C. C. WANG. China Geol. Surv., *Geol. Bull.*, No. 18, pp. 23–37 (Feb., 1932). (*J.I.S.I.*)

BULLETIN

Heat Conductivity of Ceramic Refractory Materials. Calculations of Heat Conductivity from the Constituents. A. EUKEN. *Forschungsheft*, No. 353 (Supp. to Forschung auf dem Gebiete des Ingenieurwesens); *Technische Blätter deut. Bergwerkszeitung*, **22** [5], 243 (1932); abstracted in *Metals & Alloys*, **3** [12], 360 (1932); for abstract see *Ceram. Abs.*, **11** [11], 576 (1932). E.P.R.

PATENTS

Sectional furnace wall. D. S. JACOBUS (Fuller Lehigh Co.). U. S. 1,901,560, March 14, 1933.

Checker brick and checker work formed therefrom. J. W. WAGSTAFF. U. S. 1,902,348, March 21, 1933.

Furnace wall. OSCAR NYGAARD. U. S. 1,903,062, March 28, 1933.

Rotary kiln or drum furnace with lifter bars or blades formed of silicon carbide. H. VON FERBER. Brit. 359,845, Feb. 24, 1931. (*C.A.*)

Resistance devices. VEGA LABORATORIES CORP. Brit. 363,017, Sept. 24, 1930. (*C.A.*)

Production of alumina and alkali phosphates. CHEMISCHE WERKE VORM. H. & E. ALBERT. Brit. 389,359, March 22, 1933.

Ceramic masses. FELIX SINGER. Ger. 536,799, Dec. 19, 1926. Masses consisting of BaO, Al_2O_3, and SiO_2 are given an increased resistance to the action of bases by heating to the 2 phases, glass and celsian, with prevention of formation of spinel, *i.e.*, to temperatures between 1200 and 1700°, for 24 to 200 hr. The duration of the heating determines where celsian ($BaO \cdot Al_2O_3 \cdot 2SiO_2$) or sillimanite ($Al_2O_3 \cdot SiO_2$) and mullite ($3Al_2O_3 \cdot 2SiO_2$), with $BaSiO_3$ or BaAl silicate, are formed. (*C.A.*)

Casting refractory materials. CORNING GLASS WORKS. Ger. 561,038, Oct. 5, 1928; see also U. S. 1,700,288 (*Ceram. Abs.*, **8** [4], 279 (1929)). (*C.A.*)

Refractory materials. RUDOLF RADEMACHER AND EBERHARD GOEBEL. Ger. 563,055, July 24, 1926. Refractory materials contaminated with Fe are heated to between 300 and 600°, freed from Fe as far as possible by magnetic separation, heated again to 900 to 1200°, and again subjected to magnetic separation. (*C.A.*)

Treatment of articles from refractory metal carbides. FRANZ FEHSE (Fried. Krupp A.-G.). Ger. 564,081, March 15, 1931. A method is described of altering the size or shape of articles prepared by sintering a refractory metal carbide in the presence of an auxiliary metal of lower melting point. The article is treated uniformly or locally with a corrosive gas, *e.g.*, air at 800°, whereby a layer readily removable by brushing, etc., is formed on the article. After removing this layer, the treatment is repeated if necessary. (*C.A.*)

Refractory material. BORGESTAD FABRIKKER. Norw. 47,286, Dec. 28, 1931. The material is characterized by a content of chrome-free and titanium-free oxidic Fe compounds in amounts of 5 to 50% together with Mg_2SiO_4 in amounts of 30 to 95%. (*C.A.*)

Building material, particularly for thermic and chemical purposes. BORGESTAD FABRIKKER. Norw. 47,407, Dec. 28, 1931. The material described consists of natural olivine rock (peridotite, dunite). (*C.A.*)

Refractory material. BORGESTAD FABRIKKER. Norw. 49,682, Nov. 16, 1931. More or less finely divided chrysolite rock is mixed with a binder, formed, and fired. Addition to 47,407 (see preceding patent). (*C.A.*)

Refractory materials. BORGESTAD FABRIKKER. Norw. 50,149, Feb. 1, 1932. Iron-containing Mg silicates, particularly natural rocks rich in Mg_2SiO_4 and containing

substantial amounts of Fe, such as certain chrysolites, with or without other Mg silicates such as serpentine, are mixed with adequate amounts of Mg compounds such as MgO, $MgCO_3$, etc., and hardened by heating to high temperatures without fusion in order to convert Fe into Mg ferrite and the free or liberated SiO_2 into Mg_2SiO_4. (*C.A.*)

Silicon carbide. GOTTHARDWERKE A.-G. FÜR ELEKTROCHEM. INDUSTRIE AND ARTURO PAOLONI. Swiss 154,108, March 26, 1931. Apparatus for making stones, plates, brick, tubes, etc., of SiO is described. (*C.A.*)

Terra Cotta

Kiln atmosphere for firing stoneware bodies. M. HAUSER. *Tonind.-Ztg.*, **57** [12], 137–39 (1933).—For more than twenty years, the firing of stoneware bodies in an oxidizing or a reducing atmosphere has been discussed. H. states that firing should be performed in an oxidizing atmosphere (*Ceram. Abs.*, **12** [3], 114 (1933)). Carbon deposits in the body may cause large bubbles if carbon, iron oxide, and carbon dioxide are present at the same time. Carbon should be removed by an oxidizing firing. As pointed out by Dorfner, who advocates a reducing atmosphere (*ibid.*, **12** [5], 196 (1933)), depositing carbon will not increase the strength of stoneware products. The best firing schedule is to bring as small an amount of coal as possible into the furnace at short intervals. W.M.C.

Firing stoneware in a reducing atmosphere. E. TUSCHHOFF. *Tonind.-Ztg.*, **57** [16], 189–90; [18], 210–12 (1933).—T. discusses the papers by Hauser and Dorfner (see previous abstract). Analysis of a stoneware raw material showed a large quantity of carbon and iron oxide. After oxidizing the carbon, a reducing fire should be maintained until the body is a gray color. W.M.C.

Firing of roofing tile at low temperatures. H. HIRSCH. *Tonind.-Ztg.*, **57** [9], 99 (1933).—Tile were made from a clay high in lime. Tile fired at a low temperature are less permeable to water than those fired at a high temperature. Brick fired at low temperatures, however, will not withstand freezing tests as well as high-fired brick. Only careful investigations will show whether, for a given clay, the firing temperature may be decreased from present conditions. W.M.C.

Rationalization in the chemical factory. New results in stoneware standardization. F. PLINKE. *Chem. Fabrik*, pp. 236–37 (1932).—Proposed specifications on acid-proof flange connections are given. *Ibid.*, p. 31 (1933).—Specifications are offered for flanged 3-way plug cocks. (*C.A.*)

Bright engobes and freezing behavior. K. MILLER. *Tonind.-Ztg.*, **57** [12], 139–40 (1933).—Roofing tile which, under ordinary conditions, shows an excellent resistance against freezing may crack after engobing. This is caused by a different thermal expansion of the body and the engobe, resulting in heavy internal strain. Cracks may occur if the size and distribution of surface pores are changed by engobing or by the deposition of carbon. W.M.C.

Corrosion of acid-resisting ceramic materials. M. I. NEKRITSCH. *Zhur. Prikladnoi Khim.*, **5** [8], 946–49 (1932).—Acid-resisting ceramic materials used for storing sulfuric acid were considerably corroded by the acid. The kind of corrosion and reasons for it are discussed. M.V.K.

Charm of the pantile. III. ANON. *Brit. Clayworker*, **41** [491], 390*a–c* (1933).—The development of the Roman, double Roman, Flemish, and Dutch interlocking tile is discussed. For Parts I and II see *Ceram. Abs.*, **12** [5], 197 (1933). R.A.H.

PATENT

Facing tile or slabs. G. E. HEYL. Brit. 388,340, March 1, 1933.

White Wares

Manufacture of porcelain. DUEFFE. *Ind. Silicati*, **10** [4], 9–11; [5], 11–13; [6], 10–13; [7], 10–12; [8], 10–12; [9], 10–12; [11], 12–13 (1932); **11** [2], 10–12 (1933).—A detailed discussion is given of (1) plastic materials, (*a*) kaolin and (*b*) clay; (2) thinning materials, (*a*) feldspar, (*b*) quartz, (*c*) feldspathic materials, (*d*) calcium carbonate, (*e*) magnesite, and (*f*) dolomite; (3) tests for raw materials, (*a*) selec-

tion of samples, and (*b*) methods of testing, including mechanical, rational, and general chemical analysis, firing tests, determination of fusibility and refractoriness, test for softening on heating, and determination of plasticity and binding power; (4) preparation of the mass, (*a*) subdivisions and compositions of the various porcelains, (*b*) action of each raw material in the mass, (*c*) calculation and testing of the mass and the introduction of new raw materials, (*d*) preparation of the raw materials, and (*e*) preparation of the body; (5) shaping. M.V.K.

Influence of the plastic clay content on the breaking of porcelain ware. F. M. LOPUKHA. *Keram. i Steklo*, 9 [1], 18–19 (1933).—Experimental data show that the main reason for the breaking of Russian porcelain ware is the low plasticity of the raw mass. M.V.K.

Scientific study of principal products for house floorings. I. F. CHALAMEL. *Rev. mat. constr. trav. pub.*, No. 281, pp. 27–29*B* (1933).—C. discusses (1) classification of products used: (2) nature of products, (*a*) stoneware, (*b*) terra cotta, (*c*) unfired products, and (*d*) products with a magnesia cement base with their physical and chemical characteristics. See also *Ceram. Abs.*, **11** [3], 189 (1932). M.V.K.

Tension measurement according to Steger as a plant control in the production of sanitary ware. GÜNTER HAMMER. *Ber. deut. keram. Ges.*, **13** [12], 557–68 (1932).—Results of determination of tension run on several sanitary ware bodies and glazes fired to varying temperatures are presented, and an explanation of the application thereof in setting up plant control is given. E.J.V.

Reminiscences of old-time potters. ANON. *Pottery Glass Rec.* [Eng.], **15** [1], 9; [2], 41; [3], 85 (1933).—Facts relating to English potteries beginning with the Middle Ages are given. M.V.K.

PATENTS

Reinforced block structure for electric fixtures. J. G. JACKSON (Square D Co.). U. S. 1,901,165, March 14, 1933.

Transmission line device. C. F. WAGNER AND L. R. GOLLADAY (Westinghouse Electric & Mfg. Co.). U. S. 1,901,572, March 14, 1933.

Cable terminator cap assembly. J. C. RAH (Delta-Star Electric Co.). U. S. 1,901,666, March 14, 1933.

Cable terminator. J. C. RAH (Delta-Star Electric Co.). U. S. 1,901,667, March 14, 1933.

Cable terminator provided with means for insulating ends of cable sheaths. J. C. RAH (Delta-Star Electric Co.). U. S. 1,901,669, March 14, 1933.

Horizontal break disconnecting switch. ALFRED ALSAKER, W. O. HAMPTON, AND C. A. KOERNER (Delta-Star Electric Co.). U. S. 1,901,688, March 14, 1933.

Method of making insulator caps. B. A. PLIMPTON (Locke Insulator Corp.). U. S. 1,902,310, March 21, 1933.

Ceramic catalyzer. A. M. FAIRCHILD (Mantle Lamp Co. of America). U. S. 1,902,630, March 21, 1933.

Means for holding all potters tools for shaping and profiling earthenware in clay state. C. BAILEY. Brit. 387,816, Feb. 22, 1933.

Manufacture of pottery ware. W. J. MILLER. Brit. 388,645, March 8, 1933.

Lavatory basins, sinks, etc. TWYFORDS, LTD., AND J. T. WEBSTER. Brit. 389,047, March 15, 1933.

Water closet flushing cisterns. O. A. E. JACOBSEN. Brit. 389,059, March 15, 1933.

Porcelain products. AUGUSTIN A. L. J. DAMIENS. Fr. 735,357, June 9, 1931. A plastic paste is made of a mixture of a crystalline powder, natural or artificial, with a gelatinous or colloidal precipitate obtained artificially and having the same composition or a composition near to that of the crystallized substance. The paste is formed, dried, and fired. (*C.A.*)

Metals on porcelain. LA PORCELAINERIE DE LESQUIN. Fr. 737,035, May 13, 1932. Ag is precipitated from an acid solution of $AgNO_3$, washed, mixed with Bi subnitrate, and applied as a paint to porcelain. The whole is calcined at about 800°. (*C.A.*)

Device for applying glaze to earthenware. HANS HARDEGGER. Ger. 563,606, Jan. 7, 1932. (*C.A.*)

Casting ceramic articles. HERMSDORF-SCHOMBURG-ISOLATOREN G. M. B. H. Ger. 566,275, Sept. 6, 1930. Hollow ceramic articles, the walls of which are to be thicker at certain parts, are cast in porous molds so constructed that the porosity of the mold wall is greater at the parts where a greater thickness in the wall of the article is required. A suitable mold is described. (*C.A.*)

Equipment and Apparatus

Thermoelectric properties of platinum-rhodium alloys. FRANK R. CALDWELL. Bur. Stand. *Jour. Research*, **10** [3], 373–80 (1933).—The thermal electromotive forces and thermoelectric powers of a series of platinum-rhodium alloys have been determined against pure platinum from 0 to 1200°C. R.A.H.

Developments in high-temperature alloys in the nickel–cobalt–iron system. C. R. AUSTIN AND G. P. HALLIWELL. Amer. Inst. Mining Met. Eng. *Tech. Pub.*, No. 430, pp. 1–21 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 18 (1932).—The investigation deals with the development of the "Konel" series of alloys which are essentially nickel-cobalt-iron with small quantities of other elements, principally about 2.5% of titanium. About 80% of the maximum aging hardness was obtained with most of the alloys by heating at 650°C for 72 hr. Certain of the alloys, however, showed no marked age-hardening properties, and it is suggested that the predominating factor in determining this is the titanium addition. Aging persists over long periods at relatively high temperatures. F.G.H.

Nimol, a new high alloy cast iron. EDWIN WALKER. *Sands, Clays, & Minerals*, **1** [2], 45–50 (1932).—Nimol is a high-grade cast iron heavily alloyed with nickel, copper, and chromium. It is resistant to oxidation and other forms of chemical attack up to about 820° and it is particularly free from "growth" at such temperatures, an important attribute in view of the troublesome growth of cast iron. The chief industries in which Nimol is suitable are (1) the glass industry, for the hot section of glass annealing furnaces, neck molds, press and blow molds, plate-glass rolls, and glass annealing furnace parts; (2) ceramics, for castings in enameling stove parts (lasting 6 to 7 months as compared with 10 days for ordinary iron), in enameling bath tubs, parts for porcelain kilns, and supports for furnace bottoms. Other industries using Nimol are discussed. M.V.K.

Heat-resisting alloys. J. F. KAYSER. *Foundry Trade Jour.*, **45** [802], 412–14 (1931); abstracted in *Mech. Eng.*, **54** [5], 379 (1932); see also *Ceram. Abs.*, **12** [4], 143 (1933). F.G.H.

Cemented tantalum carbide, a new tool material. ANON. *Metal Progress*, **19** [3], 53–55 (1931); abstracted in *Jour. Inst. Metals*, **50** [4], 261 (1932).—The manufacture and properties of tantalum carbide cemented with about 8% nickel are described. This carbide melts at about 4400°C, while tungsten carbide melts at 2700°C. Its heat conductivity is abnormally low, being about one-third that of tungsten carbide. Cutting tests give satisfactory results in coolness and speed. There is little thermal expansion, and the life of tools is stated to be equal to that of tungsten carbide tools. F.G.H.

Mechanical properties of metals at high temperatures. J. GALIBOURG. *Sci. et ind.*, **15**, 455–62 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 41 (1932).—A summary is given of important work on the following types of high-temperature tests: hardness, shock, torsion, bending, fatigue, and friction. A bibliography is included. F.G.H.

Black body for high temperature research heated by means of high frequency. C. MÜLLER, H. THEISSING, AND W. ESMARCH. *Z. tech. Physik*, **14** [3], 107–10 (1933).—A new type of black body was constructed for investigating light standards, melting-point determinations, and spectroscopic work. A tungsten tube of 6 mm. inside diameter and heavy walls is enclosed by alternate layers of thoria, molybdenum, and zirconia, the parts exposed to the highest temperatures being made of tungsten and thoria. A water-cooled induction coil is used for heating the furnace with a current of 10,000 v. Temperatures up to 3000°K may be obtained by filling the furnace with pure nitrogen of 50 mm. pressure. In a vacuum, 2300°K only will be obtained, as at higher temperatures the thermal sputtering of the tungsten is heavy. W.M.C.

New high-temperature experimental furnaces. ANON. *Brit. Clayworker*, **41** [491], 386 (1933).—A brief description is given of the Degussa Lilliput furnace which is operated with gas. Using gas of normal heat value, a temperature of 1750 to 1900°C can be attained in about 20 min. R.A.H.

Modern steels applied to clayworking. ANON. *Brit. Clayworker*, **41** [491], 384–85 (1933).—Of special interest is the high-frequency electric crucible furnace for making tool steels. A recently developed steel alloy for lining brick and tile press boxes has three times the life of linings previously used and gives a superior product. Special alloy steels for knives in mixing machines, plates in crushing and grinding machines, and liners for ball mills are discussed as well as stainless and drill steels. R.A.H.

Electric furnace for tensile tests at high temperatures. O. BECKMANN. *Metallwirtschaft*, **10**, 725–26 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 40 (1932).—A furnace for making tensile as well as endurance tests under constant load in a tensile

machine at temperatures up to 1000°C is described together with a mirror arrangement for the measurement of small elongations. F.G.H.

Use of high-frequency furnaces in laboratories. W. KROLL. *Metallwirtschaft*, **10**, 751–54 (1931); abstracted in *Jour. Inst. Metals*, **50** [3], 170 (1932).—Operations involved in the use of a Lorenz furnace and a Ribaud furnace are described. For temperatures up to 2000°C, crucibles made from powdered fused alumina, fused crystalline magnesia, or powdered pressed magnesite have proved satisfactory. F.G.H.

Resistance material for electric furnaces for high temperatures. G. NORDSTRÖM. *Chem. Zentr.*, **103**, 1810 (1932); abstracted in *Jour. Inst. Metals*, **50** [6], 393 (1932); for abstract see *Ceram. Abs.*, **12** [4], 167 (1933). F.G.H.

Laboratory furnaces and temperature regulators. P. CHEVENARD. *Rev. Mét.*, **28**, 453–68 (1931); abstracted in *Jour. Inst. Metals*, **50** [3], 171 (1932).—The influence of the nature and mode of wiring on nonuniformity of temperature is determined by direct observations of temperatures within the furnaces. F.G.H.

Arrangement for measuring thermal dilatation at high temperatures and some test results obtained. ELISABETH LUX. *Ber. deut. keram. Ges.*, **13** [12], 549–56 (1932).—A specially made Tammann furnace, so constructed that the ends of the test piece can be observed through special sighting tubes of sillimanite, is described. The ends of the furnace are closed and temperature readings are obtained with an optical pyrometer. The advantages of this type of furnace are enumerated, and results obtained in test runs on various materials heated up to 1700 to 1800°C are given. E.J.V.

Temperature regulator for melting furnaces. H. RECHENBERG. *Elektrotech. Z.*, **52**, 1498–99 (1931); abstracted in *Jour. Inst. Metals*, **50** [2], 94 (1932). F.G.H.

Measuring temperature in the foundry. M. CLAIN. *Rev. fonderie moderne*, **25**, 363–65 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 44 (1932).—Descriptions of the construction of thermoelectric, total-radiation, and disappearing-filament types of pyrometer are given and the principles on which they work are explained. F.G.H.

Thermal insulation by means of aluminum foil. ANON. *Rev. gén. sci.*, **42**, 626–27 (1931); abstracted in *Jour. Inst. Metals*, **50** [3], 182 (1932).—The emissivity of polished aluminum is sensibly equal to 8% of that of a black body and thus forms an excellent outer container for furnaces, etc. F.G.H.

Thermocouple elements improved. ANON. *Oxy-Acetylene Tips*, **10**, 71–76 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 54 (1932).—Joins in both base metal and the platinum group metals for use as thermocouple wires are more satisfactorily effected by the oxyacetylene process. F.G.H.

Simple method of calibrating laboratory thermocouples. D. E. FREAR. *Chemist-Analyst*, **20** [6], 16 (1931); abstracted in *Jour. Inst. Metals*, **50** [3], 175 (1932).—Pieces of metal of known melting point are placed across the ends of the nickel wires to close the circuit, and the reading of the millivoltmeter is taken when the metal melts and breaks the circuit, causing the lamp to go out. F.G.H.

Thermocouples. H. W. LAMSON. *Rev. Sci. Instruments*, **3**, 57 (1932); abstracted in *Jour. Inst. Metals*, **50** [3], 175 (1932).—L. describes three types of thermocouples or thermoelements designated as mutual, contact, and separate heater types. Reference is made to commercially available contact and separate heater types mounted in evacuated containers. F.G.H.

X-ray camera for powder diagrams at any temperature. NELSON W. TAYLOR. *Rev. Sci. Instruments*, **2** [11], 751–55 (1931); abstracted in *Metals & Alloys*, **3** [8], 240 (1932).—A cylindrical X-ray camera of about 57-mm. diameter may be used for powder photographs (Hull-Debye-Scherrer method) up to 1000°C or down to liquid air temperatures. Convenience in use is obtained by placing the film on the outside rather than on the inside. Using a Siegbahn type X-ray tube with Cu or Fe anticathode and 15 to 20 milliamperes tube current, good diagrams may be obtained in 10 min. to 2 hr., depending on the substance being investigated. The method permits the study of those crystal modifications which are stable at high or low temperatures but unstable at room temperature. Lattice constants may be determined to an accuracy of 0.2%. See also *Ceram. Abs.*, **10** [3], 207 (1931). E.P.R.

X-ray apparatus for powder analysis. G. GRIME. *Jour. Sci. Instruments*, **8**, 197–99 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 41 (1932). F.G.H.

Extruding machine with movable mouthpiece. LANGER. *Tonind.-Ztg.*, **57** [17], 196 (1933).—By making the mouthpiece movable in order to adjust its distance from the shaft of the machine, satisfactory products should be obtained under all conditions. W.M.C.

Fundamental properties of mouthpieces for brick machines. ANON. *Tonind.-Ztg.*,

57 [21], 248 (1933).—The clay column should leave the mouthpiece of the extruding machine at a rate uniform on all sides. W.M.C.

Electro-lubrication of clayware dies. J. O. EVERHART. Presented at Meeting of American Ceramic Society, Feb., 1933; abstracted in *Brick Clay Rec.*, **82** [3], 97–98 (1933). E.J.V.

Automatic mixing and feeding devices in the brick industry. A. ASMUS. *Tonind.-Ztg.*, **57** [23], 275–76 (1933). W.M.C.

Commercial de-airing of clays. B. T. BONNOT. Presented at Meeting of American Ceramic Society, Feb., 1933; abstracted in *Clay-Worker*, **99** [3], 107 (1933). E.J.V.

Fan, blower, and suction pipe systems. JOHN W. ROMIG. *Glass Ind.*, **14** [4], 41–43 (1933).—Blowpipe systems are used to conduct air or gases at a low pressure for processes, ventilation, heating, and combustion. The pipes or ducts are usually made of black or galvanized sheet iron. Round ducts should be used wherever possible because of ease of fabrication, erection, greater effectiveness, etc. The best angles to use in making branches are discussed. Tabular data regarding pressures or suctions for different sizes of ducts, different types of work, etc., are given and their use is explained in detail. Formulas for necessary calculations are also explained. The chief items to be considered in installing blower or suction systems are enumerated. E.J.V.

Cottrell's dust-collecting method. I. KIYOSHI SHIGA. *Jour. Jap. Ceram. Assn.*, **40** [480], 779–89 (1932).—The theory and practice of the electric precipitation process are illustrated and S.'s new theoretical formulas are explained. (1) Velocity of minute particles in the electric field. According to Stokes, when a minute spherical particle with radius r migrates with a velocity v through a gas whose viscosity is η, the resistance W acting on the grain can be expressed by the equation $W = 6\pi\eta rv$. If a minute particle is in an electric field, the intensity of the electric force $(F)el$ acting on it is $(F)el = ne_0E + r^3/_2\cdot(\epsilon - 1)/(\epsilon + 2)\cdot dE^2/dx$; where e_0 = charge of an electron or 4.7×10^{-10} E.S.U., ne_0 = charge of the particle, E = intensity of the field, r = radius of the particle, and ϵ = its dielectric constant. As r is generally very small, the second term is negligible. Hence $(F)el = ne_0E$. Putting $(F)el = W$, we have $ne_0E = 6\pi\eta rv$. Therefore, $v = ne_0/(6\pi\eta r)\cdot E \ldots$ (1). Let r' denote the radius in $\mu\mu$, then the result of W. Deutsch (*Z. tech. Physik*, pp. 423–37 (1925)) becomes as follows:

r'	10^4	10^3	10^2	10
n	4640	376	28	2

S. expressed the relation between r' and n by the linear equation $n/r' = a + b \log r'$; where $a = 0.108$ and $b = 0.0888$. Putting this in (1), S. obtained the equation, $v = e_0/(6\pi\eta)\cdot(c_1 + c_2 lnr)\cdot E\cdot 10^4 \ldots$ (1′); where $c_1 = 7.296$, $c_2 = 0.386$, and $lnr = 2.3026 \log_{10}r$, all units being of c.g.s. The relation $dv/dr > 0$ shows that the coarser the particle is the more easily it can be collected. (2) The precipitation efficiency. For the tube-type collector, in which the radius of grounded tubes = R, the time of the action of electric field upon the particle = T, the velocity of the particle in the equation (1) for unit electric field = v_1, and the intensity of the field = E, the precipitation efficiency ϵ is $\epsilon = 1 - e^{-2EV_1/R\cdot T\epsilon} \ldots$ (2); where e is the base of natural log or 2.7183, and v_1 is a function of r and η as shown in (1′). S.K.

Conveyer systems that reduce production costs. ANON. *Mech. Handling*, **18** [12], 403–404 (1931); abstracted in *Mech. Eng.*, **54** [4], 308 (1932).—A review is given of various conveyer systems that reduce operating costs by reduction of manual effort. Cost comparisons of the various systems are made. F.G.H.

New elutriator. A. L. CURTIS. *Sands, Clays, & Minerals*, **1** [3], 59–63 (1933).—The principle of elutriation consists essentially in subdividing the size of fine mineral particles (too fine for classification by screening) into their various sized groups by physical action. Water and air are usually the two media by which this division is made. The theory of elutriation is discussed and the Andrews' kinetic elutriator is described. M.V.K.

Nickel-chrome processes. HANS HORNAUER. *Emailletech. Monats-Blätter*, **9** [3], 20–22 (1933).—Details of several different chrome plating processes are given, showing the effect of different temperatures of the plating baths, their compositions, etc., on the resultant plated coating. See also *Ceram. Abs.*, **11** [9], 497 (1932). E.J.V.

Corundum bearings. E. G. SANDMEIER. *Mech. World*, **93** [2405], 97–98 (1933).—An account of how the synthetic stone and the bearings are made is given. E.P.R.

Metallographic polishing machine. E. LEITZ CO. *Instrument World*, **4**, 118 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 40 (1932). F.G.H.

Electrical apparatus for measuring small displacements. S. REISCH. *Z. Hochfrequenztech.*, **38**, 101–11 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 40 (1932).—The

displacement to be measured moves a condenser plate and the changes in the capacity of the condenser are magnified by means of a circuit wherein the current flowing is linearly proportional to the displacement. F.G.H.

Use of quartz balls in industry. F. M. LOPUKHA. *Keram. i Steklo*, **9** [1], 17–18 (1933).—It has been found that (1) quartz balls have a constant coefficient of grinding, (2) porcelain masses ground with quartz balls are purer than those ground with porcelain or flint balls, and (3) quartz balls are more durable and economical than porcelain or flint balls. M.V.K.

Naeser color pyrometer. M. A. VERNON. *Metallurgia*, **7** [41], 159–60 (1933).—A new optical pyrometer in which temperature measurements depend upon variation in color is described. It is claimed that absolute error is less than with the usual type of optical pyrometer. M.V.K.

BOOK AND BULLETIN

Art of Drying. (Die Trockentechnik.) M. HIRSCH. 2nd ed. Julius Springer, Berlin, 1932. 484 pp. Reviewed in *Mech. Eng.*, **54** [6], 450 (1932).—This book gives a comprehensive presentation of the scientific principles of drying processes with a systematic description of these processes and the machinery for carrying them out. The theory of drying and the scientific data available to the designer are treated, and the various methods and machines in use and their application to various materials are discussed. F.G.H.

Explosive shattering of minerals. R. S. DEAN AND JOHN GROSS. Bur. Mines *Rept. of Invest.*, No. 3201. 19 pp. Free. In a preliminary report made a year ago it was shown that certain minerals when subjected to heating with water under high pressure and temperature were shattered upon the sudden release of the pressure. Explosive shattering offers possibilities as a means of reducing grinding costs. The report presents the details of a study of the mechanism of the shattering process and gives results obtained on a selected group of ores. It was noted that (1) explosive shattering of minerals and ores is most probably related to aggregate structure; (2) many ores can be reduced to fine sizes advantageously by explosive shattering; and (3) differential shattering is effective with a number of ores. See also *Ceram. Abs.*, **11** [6], 396 (1932). R.A.H.

PATENTS

Apparatus for filtering air. G. S. DAUPHINEE (American Air Filter Co., Inc.). U. S. 1,899,017, Feb. 28, 1933. C. H. GAGEN (American Air Filter Co., Inc.). U. S. 1,899,028, Feb. 28, 1933.

Tile feeder. J. A. BOWER (National Tile Co.). U. S. 1,901,281, March 14, 1933.

Drop testing machine. R. B. LEWIS (Tinius Olsen Testing Machine Co.). U. S. 1,901,460, March 14, 1933.

Electric furnace. F. A. FAHRENWALD. U. S. 1,901,499, March 14, 1933.

Interferometer. C. W. CHAMBERLAIN. U. S. 1,901,632, March 14, 1933.

Apparatus for manufacturing ceramic articles. HILMAR MUELLER (Mueller Machine Co.). U. S. 1,901,923, March 21, 1933. A machine of the character described consists of a support for material to be cut, a cutter movable through the material to a position beyond the material-sustaining surface of the support, and means for removing the cut material from the support while the cutter is in the aforesaid position.

Method of coating electrodes of discharge tubes. HORST ROTHE (Telefunken Ges. für Drahtlose Telegraphie m.b.H.). U. S. 1,902,185, March 21, 1933. The method of treating a metal electrode for electron discharge device to decrease its secondary electron emission consists in applying to the electrode a coating of chromic oxide and heating the coated electrode in an inert environment to convert the chromic oxide to chromous oxide.

Drying device for wood, brick, pottery, etc., provided with heat-recovering devices. J. G. OLSSON AND F. I. E. STENFORS (Aktiebolaget Svenska Flaktfabriken). U. S. 1,903,063, March 28, 1933.

Clay gun structures. A. F. GIESE, JR. Brit. 388,900, March 15, 1933.

Refractory metal articles. ELEKTRISCHE GLÜHLAMPENFABRIK "WATT" A.-G. Austrian 129,950, April 15, 1932. Blocks, rods, wires, etc., containing large metal crystals are prepared from refractory metals such as W or Mo by mixing the metal with a small proportion of a compound which is nonvolatile at the temperature at which the metal is sintered, but exerts an appreciable vapor pressure at the temperature to which the metal is heated in order to cause crystallization. The compounds which may be added include silicates, borates, phosphates, titanates, and fluorides. Examples are given. (*C.A.*)

Apparatus for continuous mixing of solid substances or kneading of solid substances with liquids. R. JOHANSON. Norw. 49,133, Dec. 28, 1931. The treatment is carried out on rotary disks by means of stationary sloping shovels, the angle of which can be regulated to regulate the thickness of the mass layer and its velocity over the surface of the disk. (*C.A.*)

Kilns, Furnaces, Fuels, and Combustion

Fundamentals and economies in the clay industries. XXV. ELLIS LOVEJOY. *Clay-Worker*, **99** [3], 98–99 (1933).—L. begins his discussion of kilns by taking up the use of updraft or scove kilns for firing common brick. The cost of the kiln is low, the up-keep negligible, and the sanitary conditions are the best. The fuel consumption is a minimum for periodic kilns. Details of firing, setting, etc., are given. For Parts XXIII and XXIV see *Ceram. Abs.*, **12** [5], 199 (1933). E.J.V.

Thermal output from bottom and crown channels in annular and zigzag furnaces. P. THOR. *Ziegelwelt*, **64** [3], 21–22 (1933).—Data are given on the thermal output of different parts of furnaces and T. discusses their use for drying the ware. See also *Ceram. Abs.*, **12** [5], 201 (1933). M.V.K.

Waste-heat recovery from continuous kilns. ANON. *Brit. Clayworker*, **41** [491], 387 (1933).—A brief discussion of the articles of W. Leder (*Ceram. Abs.*, **11** [1], 51 (1932)) and P. Thor (see preceding abstract) shows how the heat in continuous kilns is dissipated and the percentage that it is possible to recover. R.A.H.

Paper divisions for the ring kiln. ANON. *Tonind.-Ztg.*, **57** [12], 140–41 (1933).—The paper should not be attacked by water vapor. The glue used for mounting the paper in the kiln should be tested carefully regarding its behavior in a damp heat (water-smoking) and hot air. See also *Ceram. Abs.*, **12** [3], 123 (1933). W.M.C.

Electric furnaces. E. BARFIELD. *Distr. Elec.*, **14**, 686–88 (1931); *Power Fuel Bull.*, **6**, 137 (1931); abstracted in *Jour. Inst. Metals*, **50** [5], 332 (1932).—Various types of furnaces suitable for different processes and various industries are described and illustrated. F.G.H.

Small furnace of high output. L. SCHIELE. *Tonind.-Ztg.*, **57** [17], 197–98 (1933).—This is a small zigzag kiln, the flue gases being removed from the top part of the furnace. W.M.C.

Photoelectric control of gas furnaces. ANON. *Mech. World*, **93** [2406], 123 (1933).—Thos. Hedley and Co., Ltd., have installed photoelectric equipment in their Newcastle works to shut off automatically the main gas supply whenever the flame of the gas burners, for any reason, becomes extinguished. At the same time the induced-draft fan motor is shut down. As the supply to the photocell apparatus is taken from the fan motor through a suitable transformer, any failure of this will also cause the main gas supply to be shut off. E.P.R.

Pyroptic furnace inspection window. ANON. *Fuel Econ.*, **7** [73], 32–39 (1931); abstracted in *Jour. Inst. Metals*, **50** [2], 129 (1932).—A window suitable for furnaces operating up to 2800°F (1537°C) is briefly described. It can be removed or cleaned and is ventilated internally to prevent deposition of ash, slag, etc. F.G.H.

Automatic temperature control of direct-fired furnaces. W. A. MOORSHEAD. Presented at meeting of London Section, Soc. of Glass Tech., Jan. 11, 1933; abstracted in *Pottery Gaz.*, **58** [668], 222 (1933). E.J.V.

Heat transmission by radiation in furnaces. P. KOESSLER. *Chem. App.*, **18** [22], 245–48 (1931); abstracted in *Mech. Eng.*, **54** [4], 309 (1932). F.G.H.

Fuel Research Board Report. ANON. *Elec. Rev.*, **112** [2883], 281 (1933).—The annual report of the Fuel Research Board for the year ended March 31, 1932, has been issued by the Department of Scientific and Industrial Research. E.P.R.

Progress in fuels. ANON. *Trans. A.S.M.E.*, **55** [3], 1–5 (1933). E.P.R.

Fuels in heat-treating furnaces. H. J. GREGG. *Metal Progress*, **23** [3], 37–40 (1933). E.P.R.

Heating with heavy oil in the ceramic industry. FRIED. BIGOT. *Rev. mat. constr. trav. pub.*, No. 281, pp. 21–26*B* (1933).—B. describes (1) attempts made to use heavy oil for firing ceramic furnaces and (2) results obtained with a new furnace used for firing porcelain (biscuit). The results were satisfactory. M.V.K.

Industrial applications of fuel oil. ANON. *Mech. World*, **93** [2408], 189–93 (1933).—Many of the working exhibits pertaining to the industrial application of fuel oil shown at the British Industries Fair are described. E.P.R.

Gas-pressure regulation. G. WEHRLE. *Amer. Gas Jour.*, **134** [5], 36–39; [6],

46–48; **135** [1], 34–36 (1931); abstracted in *Jour. Inst. Metals*, **50** [2], 130 (1932).—Various types of gas-pressure regulators, designs of distribution systems, and accessories are discussed and illustrated. F.G.H.

Gas generators in glass plants. A. Torlée. *Glashütte*, **62** [45], 786–89 (1932).—The important measuring values are (1) generator resistance, (2) generator charge, (3) steam addition, (4) gas temperature, (5) gas pressure, and (6) gas composition. M.V.K.

Small gas producer used in the ceramic industry. C. Kabus. *Tonind.-Ztg.*, **57** [9], 99–102 (1933).—This producer exhibits a fixed grate, the diameter of the shaft being 3 ft. 7 in. It may be used in connection with five muffle kilns. Operating details and graphs are given proving that the small producer is more economical than direct firing. W.M.C.

Service and supervising of installations producing gas. A. Torlée. *Glashütte*, **63** [2], 25–27; [3], 44–46 (1933).—An explanation of gasification processes is given and the most important points in the service of gas generators are discussed. The relation of the chief measuring values, generator resistance and charging, gas pressure and analysis, and bases for measuring them are given; up-to-date measuring apparatus and their regulation are also treated. M.V.K.

Industrial furnaces for gas. L. E. Biemiller. *Amer. Gas Jour.*, **136** [1], 32–34 (1932); abstracted in *Jour. Inst. Metals*, **50** [4], 270 (1932).—Thermostatic devices, pyrometers, and thermostatic pilot lights employed with gas-fired furnaces are briefly described. F.G.H.

Radiation and burned gases. A. Foch. *Chaleur et ind.*, **13**, 281–85 (April, 1932).—F. discusses the theory of radiation with particular reference to the case of radiation from burning gases. (*J.I.S.I.*)

General properties of steady temperatures in solids partially exposed to gas. R. V. Churchill. *Physics*, **4** [2], 50–55 (1933).—Five general properties of steady temperatures in solids of arbitrary shape are derived. Although the derivations are mathematical they depend almost solely on the fundamentals of the mathematical theory of heat conduction. The solid has any portion of its surface held at a fixed temperature distribution and the rest exposed to gas. The rate of transfer of heat between gas and surface is assumed to be any function of the position of the point and the temperature of the surface for a given state of the gas. For a fixed temperature this function is called the emissivity. Briefly stated, the important properties are as follows: (1) In two geometrically similar solids exposed to the same surface temperature conditions at corresponding points, except that their emissivities are inversely proportional to their sizes, the temperatures at corresponding points are equal; (*a*) if the entire surfaces of two geometrically similar solids are given fixed temperature distributions, the temperatures at corresponding points are equal everywhere if they are equal on the surfaces. (2) An increase in the size of a solid causes the same temperature change as an increase in its emissivity. (3) An increase in the size of a solid causes an increase in the temperature at each point if the solid is receiving heat from the gas, and a decrease if the solid is losing heat to the gas. (4) From Newton's law of surface heat transfer there follows a linear relation between the steady temperature at any point and the uniform temperatures of the gas and the fixed-temperature surface. These properties are discussed at the end of the paper. Some of the results of (4) seem contrary to expected results. C. develops the mathematical values and relations of these factors.

Analysis of solid fuels, especially their distillation under vacuum at increasing temperatures. L. B. de Mongeot. *Giorn. chim. ind. applicata*, **13**, 411–13 (1931); abstracted in *Jour. Inst. Metals*, **50** [6], 395 (1932).—M. proposes to submit the coal to vacuum distillation. A weighed sample in a quartz boat is placed in a combustion tube connected to a gas collector. Vacuum is applied and the coal is rapidly heated to 400°C. Gases are collected as liberated at 400 to 600°C, and 600 to 1000°C. Curves show that the cubic centimeters of gas evolved at various temperatures are similar for similar types of fuels. F.G.H.

Possibilities of using coal and lignite briquets in traveling grates. Konrad Weiss. *Feuerungstechnik*, **21** [1], 4–9 (1933).—Different experiments are described. Tables and diagrams illustrate the article. M.V.K.

Calculation of the calorific value of coal. De Cahier. *Gas World*, **95**, 596–99 (1931); abstracted in *Jour. Inst. Metals*, **50** [4], 272 (1932).—Formulas proposed for the calculation of the calorific value of coals based on ultimate or proximate analyses are briefly and critically reviewed. F.G.H.

Rational analysis of coals. R. V. Wheeler. *Power Fuel Bull.*, **4**, 62 (1931); abstracted in *Jour. Inst. Metals*, **50** [6], 394 (1932).—The properties of coals are not

related directly to the proportions of carbon and hydrogen because of the heterogeneous nature of the coal, the individual substances it contains having different elementary compositions. The methods of rational analysis described make it possible to determine an approximately quantitative separation of (1) free hydrocarbons, (2) resins, (3) structural plant entities which have resisted decay, such as spore extines and cuticular tissues, and (4) ulmins, the condensation products of the cellular tissues and proteins of the plants. Some typical rational analyses of British coals are given in a table. F.G.H.

British coals. A. L. CURTIS. *Sands, Clays, & Minerals*, **1** [3], 65–75 (1933).—The origin, composition, and classification of British coals are discussed in detail. A table with coal analyses is given. M.V.K.

Influence of dimensions of solid fuel on combustion. W. MATHESIUS. *Rev. mét.*, March, 1931; abstracted in *Rev. mat. constr. trav. pub.*, No. 279, pp. 233–34*B* (1932).—The reactions taking place during combustion are discussed in detail and formulas for calculating the dimensions of solid fuel are given. M.V.K.

Drying of tender clays. O. PHILIPP. *Tonind.-Ztg.*, **57** [15], 173–74 (1933).—Shaping and preparing the body will influence the drying properties of ceramic products and the plasticity and shrinkage. Satisfactory results may be obtained by drying with air having a decreasing moisture content. For economical reasons, the products should never stay longer than 5 or 6 days in the drying chambers. The kiln should be kept tight and in good repair. Increasing firing speed will result in plenty of waste heat for the drying chambers. W.M.C.

Flame temperatures. W. T. DAVID, W. DAVIES, AND J. JORDAN. *Phil. Mag.*, **12**, 1043–57 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 44 (1932). F.G.H.

Preliminary theory of temperature control. M. LANG. *Z. tech. Physik*, **14** [3], 98–105 (1933).—Temperature-control units are compared with controllers of rate of flow and pressure. Equations are derived which will characterize temperature control. The adjustment of the controllers for different purposes is discussed. It is shown how to take into account the lag of the controllers. W.M.C.

Heat technical control of operation. K. A. TORLÉE. *Glashütte*, **62** [46], 819–20 (1932).—The necessity and advantages of heat technical control of operation are pointed out. M.V.K.

Theory of heat transfer. W. E. STARK. *Amer. Gas Jour.*, **135** [1], 25–27 (1931); abstracted in *Jour. Inst. Metals*, **50** [2], 129 (1932).—Laws governing the passage of heat from its source to the medium to be heated are briefly discussed. Radiation from flames is not usually appreciated. F.G.H.

Temperature measurement. J. MARTERET. *Sci. et ind.*, **16**, 97–98 (1932); abstracted in *Jour. Inst. Metals*, **50** [6], 370 (1932).—Fundamental principles of heat exchange and a survey of various scales and their correlation are discussed. The merits of Kelvin's absolute scale are emphasized. A combined scale utilizing helium, hydrogen, resistance thermometers, and thermocouples, and finally optical methods is the nearest experimental realization of Kelvin's scale; the use of this composite scale is becoming general, and its wider adoption in industrial pyrometry is advocated. F.G.H.

Heat flow through granulated material. J. H. AWBERY. *Phil. Mag.*, **12** [81], 1152–55 (1931); abstracted in *Mech. Eng.*, **54** [4], 309 (1932).—A. gives a theoretical mathematical discussion of heat flow in an aggregate of exactly similar particles packed in such a manner that every one bears the same relation to its neighbors as any other. F.G.H.

Heat transfer by radiation in boiler furnaces. H. FRIEDRICH. *Mitt. Forschungsanstalten Gutehoffnungshütte Konzern*, **1** [10], 227–43 (1932); abstracted in *Mech. Eng.*, **54** [8], 576 (1932).—The theory of heat transfer by radiation and data of an elaborate series of experiments are presented. Heat radiation in the furnace from the grate and brickwork and also radiation from the gas are discussed. The simultaneous use of several suction pyrometers for the determination of flue-gas temperatures in different regions is described. The formula given by Orrok for the calculation of the radiant heat of furnaces was found to be in good agreement with experimental data. Illustrated. F.G.H.

Heat insulation in heating plants. H. SCHACHT. *Gesundh.-Ing.*, **54** [52], 757–64 (1931); abstracted in *Mech. Eng.*, **54** [4], 311 (1932).—A theoretical mathematical discussion of the principles of heat-insulation engineering is given. A simplified method of computing heat losses is described and examples from heat-insulation practice are cited. F.G.H.

BOOKS AND BULLETIN

Heat Transmission. W. H. MCADAMS. McGraw-Hill Book Co., Inc., New

York, 1932. 383 pp. 135 illustrations. Price $5.00. Reviewed in *Power*, **77** [2], 100 (1933).—The book comprises three parts, conduction, radiation, and convection. The first, composed of two chapters, deals with steady conduction, unsteady conduction, thermal conductivities, effect of shape of body, resistances in series and in parallel, etc. The second section treats of radiation between solids from nonluminous and luminous flames and the general problem of furnace design. The third, composed of seven chapters, deals with dimensional solidarity, fluid dynamics, relation between individual and overall coefficients of heat transfer, effect of scale deposits, heat exchangers, measurement of surface temperatures, fluids inside and outside pipes, condensation, and evaporation. Much of the material, collected from a variety of sources and reduced to a common basis, is presented in graphical and tabular form in order to make it more generally useful. Alignment charts are used in the solution of some equations, and illustrative problems are numerous. F.G.H.

Oil Economics. C. OSBORN. McGraw-Hill Book Co., New York, 1932. 402 pp. Price $4.00. Reviewed in *Mech. Eng.*, **54** [7], 522 (1932). F.G.H.

Tests on the continuous carbonization of finely crushed coal by radiant heat. F. B. HOBART AND D. J. DEMOREST. O.S.U. Studies, *Eng. Series*, **1** [1], 39 pp. (1932), 16 figs.; abstracted in *Mech. Eng.*, **54** [4], 286 (1932).—The economic possibilities of the White process of low-temperature carbonization and the effects of varying retort temperatures and coal sizes are discussed in detail. F.G.H.

PATENTS

Kiln. L. L. LADD. U. S. 1,903,117 and 1,903,118, March 28, 1933.

Kiln furniture. L. L. LADD. U. S. 1,903,119, March 28, 1933.

Kilns for firing brick, etc. A. GEYER. Brit. 389,192, March 22, 1933.

Firing ceramic articles. FRANCO BANDINI. Austrian 130,372, May 15, 1932. The moist, freshly molded articles are heated in a tunnel kiln while embedded in a refractory box containing a mixture of sand with a liquid or powdered fuel. (*C.A.*)

Means for heating tunnel kilns. HOLDING-GES. FÜR KERAMISCHE WERKE. Ger. 560,182, Oct. 7, 1930. (*C.A.*)

Ceramic tunnel kilns. JOSEF DANIELS (Heinrich Koppers A.-G.). Ger. 562,809, March 16, 1929. (*C.A.*)

Tunnel muffle for tile, etc. FRITZ SCHLOSSER. Ger. 564,289, Feb. 21, 1932. (*C.A.*)

Electric resistance furnace for melting glass, water glass, cement, etc. AKT.-GES. FÜR GLASINDUSTRIE VORM. FRIEDR. SIEMENS AND AKT.-GES DER GERRESHEIMER GLASHÜTTENWERKE VORM. FERD. HEYE. Ger. 564,491, Dec. 25, 1928. (*C.A.*)

Kiln for firing abrasive articles. M. D. KRAMENSKII. Russ. 25,477, Sept. 28, 1930. Construction details are given. (*C.A.*)

Rotating kiln for firing alabaster. M. B. POPLAVSKII. Russ. 25,479, Nov. 16, 1927. (*C.A.*)

Crate for firing porcelain goods in a muffle furnace. I. A. MELNIKOV. Russ. 25,480, June 27, 1930. (*C.A.*)

Geology

Tripoli powder. R. PEARMAIN. *Sands, Clays, & Minerals*, **1** [3], 43–45 (1933).—Material from Tripoli (northern Africa) is formed from siliceous shells of diatoms and other microscopic species, while the material from Seneca (Mo.) is a form of silica derived from the decomposition of chert or a residual product from the decomposition of a highly siliceous limestone containing no diatoms, but appearing amorphous under a low magnification, and of entirely different origin with different physical and chemical properties from the Algerian material. The use of Tripoli powder is described. M.V.K.

Fuller's earth. JAMES H. TAILOR. *Sands, Clays, & Minerals*, **1** [2], 29–32 (1932).—Chemical analysis of fuller's earth shows that it does not differ materially in composition from other clays, and its peculiar properties seem to be due to its physical properties rather than its chemical nature. Deposits of fuller's earth occurring in England and its different uses are described. M.V.K.

Mining English china clay. I. A. L. CURTIS. *Sands, Clays, & Minerals*, **1** [3], 13–19 (1933).—C. describes in detail (1) the genesis, properties, and characteristics of china clay, (2) commercial uses, (3) methods of recovery, and (4) purifying and drying. M.V.K.

Separation of beryl from quartz. LUIGI USONI. *Giorn. chim. ind. applicata*, **15** [1], 13–15 (1933).—Beryl can be separated from quartz with the reagents, oleate of sodium–pine oil–lead nitrate in the respective proportions of 100–150–50 g. per ton of mineral. M.V.K.

Adjusted values for the moisture content of clay. H. HIRSCH. *Ber. deut. keram. Ges.*, **13** [12], 579–82 (1932).—The consensus of opinion of a committee of ceramic technologists gave the following as acceptable moisture contents of clays: raw kaolins, 20 to 22%, washed kaolin, 8 to 12%, and fuller's earth, up to 28%. E.J.V.

Natural weathering. G. BERG. *Tonind.-Ztg.*, **57** [14], 163–64 (1933).—This is an abstract from the new book by Berg, Distribution of the Chemical Elements on the Earth (*Ceram. Abs.*, **12** [3], 126 (1933)). Natural weathering is performed by water, oxygen, and carbon dioxide. The most important process is the hydrolytic disintegration of the silicates. Under ordinary circumstances, aluminum silicates will disintegrate as follows: Alkali and part of the silica will go into solution, and aluminum hydrosilicate (kaolin) will remain. In a tropical climate, however, aluminum hydroxide alone will remain. In some cases the so-called laterite decomposition will take place after the formation of kaolin. Bauxite, it is pointed out, has been formed by this process. China clay for use in porcelain bodies will be formed only from minerals which are free from iron. W.M.C.

Examination of minerals in ultra-violet light. JULIUS GRANT. *Sands, Clays, & Minerals*, **1** [3], 7–10 (1933).—The device used for such examinations and ways of using it are described. M.V.K.

Rock sections. K. E. BUSZ. *Sands, Clays, & Minerals*, **1** [2], 35–37 (1932).—The examination of rocks with the aid of microscopes with transmitted light and the preparation of "wafer-thin" sections of the material are discussed, and the importance of such examinations is pointed out. M.V.K.

Some little-known uses of clays. ALFRED B. SEARLE. *Sands, Clays, & Minerals*, **1** [2], 42–44 (1932).—The varied uses of clays in different industries are given. M.V.K.

Use of geological maps and soil profiles. G. SCHULZ. *Tonind.-Ztg.*, **57** [20], 241–42 (1933).—The importance of a geological investigation of clay pits for small brick plants is emphasized. A typical sample is given and fully discussed. W.M.C.

Simplicity and uniformity in technical nomenclature. ANON. *Eng. Mining Jour.*, **133**, 72 (1932); abstracted in *Jour. Inst. Metals*, **50** [6], 398 (1932).—The term "diatomaceous earth" is unnecessarily cumbersome and it is misleading and illogical when referring to "earth." "Diatomite" is the correct term. This is an example of a common error in technical literature. F.G.H.

BOOKS AND BULLETINS

Treatise on Sedimentation. WILLIAM H. TWENHOFEL, *et al.* Williams and Wilkins Co., Baltimore, Md. 926 pp. Price $8.00. *Mining & Met.*, **14** [316], 201 (1933).—In the first three chapters, devoted to sources and production of sediments, terrigenous, organic, volcanic, magmatic, and cosmic sedimentary sources are studied. Chapter IV treats of sediments and organisms, V covers the products of sedimentations, VI treats of structures, textures, colors of sediments and their origin, and VII is on environments or realms of sedimentation. The last chapter concerns field and laboratory studies of sediments. See also *Ceram. Abs.*, **12** [5], 200 (1933). E.J.V.

Form and Properties of Crystals. A. B. DALE. Reviewed in *Refrac. Jour.*, **9** [2], 72 (1933).—This is an unusually well-written book for people who are beginning the study of mineralogy and crystallography. It should be especially useful to those who wish to understand the differences between quartz, cristobalite, and tridymite, the two forms of dead-burned magnesia, or the three crystalline forms of alumina. These specific instances of crystalline form are only mentioned, but articles and books dealing with them would be much more easily understood by any one who has mastered the contents of this little book. It is clearly written, does not go too far, and especial attention has been paid to the use of polarized light in determining crystals. See also *Ceram. Abs.*, **12** [4], 171 (1933). E.P.R.

Geophysical Abstracts. No. 43. F. W. LEE. Bur. Mines *Periodical Service Rept. G. A.* 43. 23 pp. 10¢. Information Section, U. S. Bureau of Mines, Washington, D. C. Recent articles, books, and patents concerning geophysical methods of prospecting are reviewed. **No. 44.** *Ibid.*, 27 pp. **No. 45.** *Ibid.*, 50 pp. An index to Geophysical Abstracts Nos. 33 to 44 inclusive is added. **No. 46.** *Ibid.*, 27 pp. For No. 42 see *Ceram. Abs.*, **12** [3], 126 (1933). R.A.H.

Clay in 1931. O. E. KIESSLING AND K. V. HERLIHY. Bur. Mines *Mineral Re-*

sources U. S. 6 pp. 5¢. Supt. of Documents, Govt. Printing Office, Washington, D. C. R.A.H.

PATENTS

Purifying natural heavy spar. JOHANNES MÜLLER ("Sachtleben" Akt.-Ges. für Bergbau und Chemische Industrie). U. S. 1,900,994, March 14, 1933.

Process of preparing titanium dioxide. FOORD VON BICHOWSKY. U. S. 1,902,203, March 21, 1933.

Process of producing pigments containing titanium. FOORD VON BICHOWSKY. U. S. 1,902,204, March 21, 1933.

Manufacture of titanium oxide. TITANIUM PIGMENT CO., INC. Brit. 387,720, Feb. 22, 1933.

Process for the manufacture of pure titanium dioxide. I. G. FARBENINDUSTRIE AKT.-GES. Brit. 388,978, March 15, 1933.

Chemistry and Physics

Revision of atomic weight of silicon. P. F. WEATHERILL AND P. S. BRUNDAGE. *Jour. Amer. Chem. Soc.*, **54** [10], 3932–38 (1932).—The mean of eight analyses made by the authors gave the value Si = 28.103 ± 0.0027. R.G.M.

Simultaneous determination of silicon, aluminum, fluorine, and orthophosphoric acid. I. T. MILLNER AND F. KUNOS. *Z. anal. Chem.*, **90**, 161 (1932).—For the analytical determination of SiO_2 and Al_2O_3 in mixtures of silico-fluorides and cryolite the boric-acid method developed by Schrenk and Ode is used, with the modification that the evaporation with boric acid is done with excess of orthophosphoric acid and, in some cases, with concentrated sulfuric acid instead of with perchloric acid. (*T.C.S.E.*)

Analysis of red lead and lead dioxide. N. BUSVOLD. *Chem.-Ztg.*, **56** [11], 106–107 (1932); *Analyst*, **57**, 268 (1932).—In search of a convenient and inexpensive method for analysis of high content lead oxides, B. tested Top's iodometric method and Lux's method. The first was found too expensive and the second inaccurate on account of occlusion of oxalic acid in the lead sulfate precipitate. A new method was devised based on the reaction, $PbO_2 + H_2O_2 = H_2O + O_2 + PbO$. Five grams of red lead were mixed with 20 cc. nitric acid of specific gravity 1.2 in a 250-cc. Philips beaker and diluted with 50 cc. of water. The mixture was titrated with 10 cc. of 30% hydrogen peroxide diluted to 250 cc. which were added in drops under constant stirring. The solution was warmed on a water bath until it was clarified. Only a small amount, about 1 mg. containing no lead superoxide, was left. This method gives better average results owing to the use of larger samples. It also supplies information on the degree of dispersion of the red lead as the coarser particles dissolve only on prolonged stirring with the glass rod. J.G.T.

X-ray investigation of the decomposition ratio in the system iron–oxide–silicic acid. PER SJÖMAN. *Tekniska Samfundets Handl.*, No. 7, 24 pp. (1930); *Chem. Zentr.*, No. 1, p. 1737 (1931).—On heating quartz with ferric oxide Fe-atoms can partially replace Si-atoms in the SiO_2 lattice. This is observed in the temperature region in which the quartz structure tends to change to cristobalite. It is probable that still another reaction takes place here, resulting in the formation of hitherto unknown Fe-silicates. Photographs and tables of experimental results are included. J.G.T.

Volumetric determination of molybdenum with permanganate. E. CARRIÈRE AND R. LAUTIÉ. *Compt. rend.*, **194**, 1167–87 (1932); abstracted in *Analyst*, **57**, 407 (1932). H.H.S.

Reduction of magnesia by silica. G. GIRE. *Compt. rend.*, **194**, 884–86 (1932); abstracted in *Sprechsaal*, **65** [30], 555 (1932).—Amorphous silica and fired MgO were pressed together in the molar ratio of 1 : 2, inserted into an iron tube, and heated in an evacuated quartz tube. The temperature of the mixture was kept at 1280 to 1320° for 3 hr. On cooling, Mg crystals were found in the colder parts of the iron tube; 60% MgO present was reduced. The formation of Mg_2Si could not be determined. M.V.K.

Using "chloramine" as a reagent in volumetric analysis. O. TOMICEK AND B. SUCHARDA. *Collection Czechoslov. Chem. Communications*, **4** [7–8], 285–99 (1932); abstracted in *Chim. & ind.*, **29** [3], 544 (1933).—Chloramine may be utilized for potentiometric determinations of a number of oxidizable substances, *e.g.*, arsenites, antimony salts, lead salts, etc. The method of procedure is described in detail. M.V.K.

Heat of formation of metacalcium silicate (wollastonite) and ferrous orthosilicate

(fayalite). W. A. ROTH AND H. TROITZSCH. *Arch. Eisenhüttenwesen*, **6**, 79–83 (1932).—A new calorimeter is described in which components of slags and cementite will be dissolved in a short time. A mixture of 20% hydrochloric and hydrofluoric acids is used, the temperature being 77°C. The heats of formation of artificial wollastonite and fayalite amount to 21.0 and 10.3 cal., respectively, at 77°C. The heat of transformation of amorphous silica, heated to about 550°C, into α-quartz was found to be 3.51 cal. at 77°C. W.M.C.

Synthetic willemite. ADRIEN KARL. *Compt. rend.*, **194**, 1743–45 (1932).—Willemite (Zn_2SiO_4) was synthesized by treating a mixture of finely ground SiO_2, NaCl, and excess $ZnCl_2$ with steam at 600° for 30 min. and treating the reaction mixture with water and then with very dilute HCl. The product obtained contained a slight excess of uncombined SiO_2. The product obtained from materials which had been carefully purified to free them from Ni and Cu exhibited a violet fluorescence when subjected to the action of cathode rays; the addition of 0.1 to 0.2% Ni gives a bright emerald-green fluorescence; the addition of 0.05 to 0.2% Cu gives a green fluorescence which turns bluish when the vacuum or the intensity of the cathode rays is increased; the addition of 0.1% Ni + 0.025% Cu gives a brilliant green fluorescence and a spectral band similar to that of natural willemite. (*C.A.*)

Character of sand grains. H. RIES AND G. D. CONSTANT. *Trans. & Bull. Amer. Foundrymen's Assn.*, **2** [10] (*Trans.*, **39**), 353–92 (1931); abstracted in *Jour. Inst. Metals*, **50** [2], 128 (1932).—The constitution, shape, and surface of the grains are described. These may influence permeability, bond strength, flowing quality, sintering, adsorption, etc. F.G.H.

Grain distribution index for sand grading. C. E. JACKSON. *Trans. & Bull. Amer. Foundrymen's Assn.*, **2** [11] (*Trans.*, **39**), 506–12 (1931); abstracted in *Jour. Inst. Metals*, **50** [2], 128 (1932).—A method is developed, based on statistical analysis, that yields a numerical value for a grain distribution index. Directions for the use of the method are given. The method is used in application to actual sand samples. F.G.H.

Nature of the latent heat of fusion. K. HONDA AND H. MASUMOTO. *Sci. Repts. Tôhoku Imp. Univ.*, **20**, 342–52 (1931); abstracted in *Jour. Inst. Metals*, **50** [1], 5 (1932).—The "dynamic internal pressure" in the solid state at the melting point has been calculated for various elements on the assumption that each atom consists of a Plank's radiator or is in simple harmonic motion. The latent heat of fusion is given by the product of the dynamic pressure and the change of specific volume during melting. It is concluded from thermodynamic considerations that a great portion of the latent heat of fusion consists of the energy of atomic rotation. For elements having a cubic lattice, (1) the dynamic internal pressure at the melting point is proportional to the square of the absolute melting point; (2) the volume increase of 1 gram-atom due to a rise of 1°C at the melting point is inversely proportional to the square of the absolute melting point; and (3) the atomic heat of fusion is proportional to the product of the volume change of 1 gram-atom during melting and the square of the absolute melting point. F.G.H.

Method of micro-determination by weight. J. DONAU. *Sitzber. Akad. Wiss. Wien, Abt. IIb*, **141** [2–3], 129–40 (1932); abstracted in *Chim. & ind.*, **29** [3], 541 (1933).—The method is based on the use of a filtration device composed of a small platinum capsule whose filtering bottom contains a layer of platinum sponge. This capsule is used in connection with another one (also of platinum) placed in the first and used for the precipitation. The method of procedure is described. M.V.K.

Micromelting-point determinations. H. LINSER. *Microchemie*, **9**, 255–68 (1931); *Analyst*, **57**, 412 (1932).—G. Klein's apparatus for micromelting-point determinations is discussed in detail and the methods of identification of chemical compounds and of finding exact values of corrections with its use are described. J.G.T.

Photomicrographs at low magnification. J. O. LORD. *Trans. Amer. Soc. Steel Treating*, **20** [1], 1–26 (1932); abstracted in *Mech. Eng.*, **54** [10], 742 (1932).—Apparatus and methods used are described for (1) polished surfaces by vertical illumination, (2) rough surfaces of low relief, and (3) rough surfaces or objects of high relief. F.G.H.

Utilization of the spectral method in chemical analysis. VITTORIO GAZZI. *Chimica*, Sept., 1932; abstracted in *Ind. chimique*, **20** [229], 97 (1933).—The advantages of the spectral analysis method for qualitative and quantitative examinations are as follows: (1) it requires only a minimum quantity of the substance, (2) it is rapid, and (3) its sensibility is much superior to that of chemical analysis. G. reviews the different sources of illumination used for the production of the spectral emission: (*a*) flame of the burner, (*b*) oxyhydrogen or oxyacetylene light, (*c*) electric arc, (*d*) spark resulting from the discharge of a condenser, and (*e*) Geissler tube. Different spectroscopes, spectrographs,

and other devices are described and their advantages are enumerated. G. insists on the fact that the solution of all problems of spectral analysis requires the use of apparatus of different types and sources of light equally varied. M.V.K.

Spectrographic analysis. E. VAN SOMEREN. *Metal Ind.* [London], **42** [12], 331–32 (1933); for abstract see *Ceram. Abs.*, **12** [5], 205 (1933). M.V.K.

Indirect method of determining humidity by means of electrical conductivity. P. P. BERG. *Liteinoe delo*, No. 8, pp. 7–8 (1931); abstracted in *Jour. Inst. Metals*, **50** [4], 269 (1932).—The determination of the absolute humidity of molding sand by measurement of the electrical conductivity is possible only in mixtures of identical composition; the results even then are inaccurate when the humidity exceeds 8%. F.G.H.

Swelling, working state, and shrinkage of clays. L. A. SHMELEV. *Trans. Ceram. Research Inst.* [Leningrad], No. 34, pp. 1–20 (1932); for abstract see *Ceram. Abs.*, **11** [9], 503 (1932). M.V.K.

Cohesion forces in soils. G. I. POKROVSKII AND V. G. BULUICHEV. *Kolloid-Z.*, **60**, 210–16 (1932).—A relation between the adhesion force, the number of particles, and distance between particles is derived. Experimental results on 2 Russian soils are in qualitative agreement with the theory, which is based on capillary forces. (*C.A.*)

Results of particle-size determination by means of Röntgen rays. FRITZ K. MAYER. *Kolloid-Z.*, **57**, 353–59 (1931).—A review is given. (*C.A.*)

Physicochemical laws of metal slag equilibria. F. KÖRBER AND W. OELSEN. *Arch. Eisenhüttenwesen*, **6**, 307–14 (1933). W.M.C.

Grain size, grain form, and the degree of division of kaolins. III. RUDOLF LORENZ. *Ber. deut. keram. Ges.*, **13** [12], 568–79 (1932).—Methods of determining the degree of division of kaolin discussed in detail are: (1) peptization of the kaolin with chemical media, using ammonia, citrates, or phosphates, (2) peptization of kaolins in mechanical ways, using viscosimeters, microscopes, grain size analyzers, the test methods of drying and firing shrinkage, the measurement of plasticity according to Pfefferkorn, and the dry stability according to Kohl, and (3) capillary pressure treatment. For Part II see *Ceram. Abs.*, **11** [12], 637–38 (1932). E.J.V.

Data. XIV. T. W. GARVE. *Clay-Worker*, **99** [3], 102–103 (1933).—G. takes up the definitions, characteristics, and classification of building brick, paving brick, and fire brick. Size, weight, strength, and absorption data on the different types are given. For Part XIII see *Ceram. Abs.*, **12** [5], 206 (1933). E.J.V.

BOOKS

Nomogram, the Theory and Practical Construction of Computation Charts. H. J. ALLCOCK AND J. R. JONES. Isaac Pitman & Sons, New York and London. 209 pp. Cloth, $3.00. *Mining & Met.*, **14** [316], 5 (1933).—The authors discuss the general theory of nomograms and give practical directions for making and using all classes of computation charts which have scientific or industrial usefulness. E.J.V.

Physico-Chemical Foundations of Colloidal Science. (Fisico-khimicheskiya osnovui kolloidalnoi nauki.) N. P. PESKOV. State Chemico-Scientific Edit., Moscow and Leningrad, 1932. 6 R., 50 kopecks. Reviewed in *Keram. i Steklo*, **9** [1], 29 (1933).—In this book, P. explains his ideas and theories on colloidal science. M.V.K.

Calculations of Qualitative Analysis. CARL J. ENGELDER. Chapman and Hall, London, 1933. 171 pp. 12s 6d net. Reviewed in *Chem. Trade Jour.*, **92** [2391], 225 (1933). M.V.K.

Colloids, Their Gels and Solutions. (Les Colloides, Leurs Gelées et Leurs Solutions.) PAUL BARY. 2d ed. Dunod, Paris. Price, bound 112.65 F., paper 102.65 F. 586 pp. *Can. Chem. Met.*, **17** [3], 35 (1933).—This second edition gives as completely as possible the results of recent work in the field of colloid chemistry, particularly its industrial applications. The general properties of matter in the colloidal state are first reviewed. This is followed by a study of the properties of gels and sols and of the phenomenon of swelling, and two chapters are devoted to mineral colloids. The subjects of organic colloids, colloidal suspensions, and emulsions are treated fully. E.J.V.

PATENT

Silicate mixtures. EMIL BÄGGLI AND EDWIN BURGER. Swiss 154,460, May 13, 1931. A mixture for making glass, porcelain, and earthenware contains essentially silicate and BeO. An example mentions a mixture of kaolin, BeO, feldspar, and quartz for making electric insulators. (*C.A.*)

General

How to value our Society. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **12** [4], 79–80 (1933).

Research and human welfare. EMERSON P. POSTE. *Bull. Amer. Ceram. Soc.*, **12** [4], 81–82 (1933).

Research, a factor in competition. WILLIAM SPRAGEN. *Bull. Amer. Ceram. Soc.*, **12** [4], 83–88 (1933).

A proposal for correlation of ceramic research. J. M. MCKINLEY. *Bull. Amer. Ceram. Soc.*, **12** [4], 89–91 (1933).

Organization and functions of the research committees of the American Ceramic Society. ROBERT TWELLS. *Bull. Amer. Ceram. Soc.*, **12** [4], 92–94 (1933).

Modern research organizations and the American patent system. F. B. JEWETT. *Mech. Eng.*, **54** [6], 394–98 (1932). F.G.H.

Is research efficient? I. R. F. WILDER. *Factory & Ind. Management*, **83** [2], 53–55 (1932); abstracted in *Mech. Eng.*, **54** [5], 382 (1932).—Lack of coördination between research, sales, and production may be largely charged to a narrow conception of the scope of market research. Failure to coördinate ideas results in specific hazards which vary with individual cases. A review is given of outstanding hazards. F.G.H.

Belt conveyers for storing materials. F. RIEDIG. *Mech. Handling*, **19** [2], 55–56 (1932); abstracted in *Mech. Eng.*, **54** [5], 380 (1932).—The operating characteristics of cranes, hoists, and belts are described. F.G.H.

Suggestions for inspection of new belting. R. C. MOORE. *Melliand Textile Monthly*, **4** [2], 116–17 (1932); abstracted in *Mech. Eng.*, **54** [9], 668 (1932).—Suggestions are offered plants that are without facilities for making physical and chemical analyses. Their belting should check with the Bureau of Standards specifications covering first quality leather belting. F.G.H.

Removal of ashes, cinders, and slag in boiler houses. J. LACASSE. *Tech. moderne*, **24** [1], 10–13 (1932); abstracted in *Mech. Eng.*, **54** [4], 307 (1932).—The handling of ashes, cinders, and slag and modern dust-removal equipment are described. Complete ash-handling equipment is illustrated in cross-section. F.G.H.

Can boiler scale be prevented by degasification? K. HOFER. *Gesundh.-Ing.*, **54** [50], 740–43 (1931); abstracted in *Mech. Eng.*, **54** [4], 308 (1932).—The possibility of preventing boiler scale formation by the removal of oxygen from the feed water is discussed. The physical and colloidal chemistry of feedwater practice is reviewed, and the effect of salt ions and of organic substances on colloidal processes occurring in the use of feed water is described. A bibliography is appended. Illustrated. F.G.H.

Comparative experiments on elutriation and dressing procedures for clays. CARL W. CORRENS AND WOLFGANG SCHOTT. *Kolloid-Z.*, **61**, 68–80 (1932). (*C.A.*)

Care of clay pits. H. KREMSKI. *Tonind.-Ztg.*, **57** [9], 102–103 (1933).—This paper deals with the clearing and depositing of the strata found on top of the clay, care of water penetrating the pit, mixing of several clays, and supervising the properties of the clay. W.M.C.

Aptitude and its relation to achievement in general chemistry. WILLIS J. BRAY. *Sci. Ed.*, **16**, 439–42 (1932). (*C.A.*)

Pulverized coal firing for fire-tube boilers. J. THIEME. *Wärme*, **55** [27], 461–63 (1932); abstracted in *Mech. Eng.*, **54** [10], 740 (1932).—Advantages of pulverized coal firing are the elimination of mechanical parts in the combustion chamber and the utilization of fine and pulverized coal with high gas content. F.G.H.

Sampling in cement plants. O. SCHOTT. *Tonind.-Ztg.*, **57** [23], 272–73 (1933).—Different methods of collecting samples of the raw materials and the different stages of the manufacturing process are outlined. Illustrated. W.M.C.

Calculation methods in brick plants. ANON. *Tonind.-Ztg.*, **57** [19], 224–25 (1933). W.M.C.

Taxable value of manufacturing properties. C. T. MAIN. *Mech. Eng.*, **54** [7], 473–75 (1932).—M. offers suggestions for obtaining a closer approximation of values for the purpose of taxation of industrial plants and their equipment. F.G.H.

Profitable wage incentive plans. H. E. STOCKER. *Materials Handling & Distribution*, **7** [3], 18–24 (1931); abstracted in *Mech. Eng.*, **54** [4], 312 (1932).—The application of wage-incentive plans to materials handling operation and characteristics of specific applications are discussed. F.G.H.

Steam boilers in pottery works and how to run them. JOHN PHILLIPS. Presented at meeting of English Ceramic Society, Feb. 13, 1933; abstracted in *Pottery Gas.*, **58** [669], 329–31 (1933). E.J.V.

Modes of action for overcoming crises. KREIDE. *Ber. deut. keram. Ges.*, **13** [11], 525–37 (1932).—A detailed explanation of an economic study of operating, production, and maintenance costs in a manufacturing plant for the purpose of obviating any critical situations in its operation is given by the National Economic Board. E.J.V.

British Industries Fair. ANON. *Pottery Glass Rec.* [Eng.], **15** [3], 66–77 (1933).—Glass, pottery, earthenware, and porcelain ware exhibited at Olympia, London, from February to March, 1933, are described. M.V.K.

Japan in British markets. ANON. *Times Eng. Supp.*, **31**, 364 (1933).—The Australian market has been completely captured by the Japanese whose pottery operatives are paid at one-quarter the rate paid in Britain, and the British market itself is suffering through Japanese imports. H.H.S.

Meeting of the German brick and clay industry. E. URBSCHAT. *Tonind.-Ztg.*, **57** [12], 135–37 (1933).—This meeting was held in February, 1933. It was attended by more than 300 visitors. A number of papers was read, and several plants were visited. W.M.C.

Polish tariff. ANON. *Tonind.-Ztg.*, **57** [14], 164–66 (1933).—The new tariff comprises "normal" and "maximum" duties. Both are given in detail, as far as ceramic products are involved. W.M.C.

BOOKS AND BULLETINS

American Society of Heating and Ventilating Engineers Guide, 1932. Published by the Society, New York. 876 pp. Reviewed in *Mech. Eng.*, **54** [5], 377 (1932).—The Guide presents concisely much definite information on heating and ventilating practice and on equipment and accessories compiled from the most reliable sources. It will prove useful to engineers, manufacturers, and building owners. The volume also contains catalogs of manufacturers of equipment. F.G.H.

The Development of American Industries. JOHN GEORGE GLOVER AND WILLIAM BOUCK CORNELL. 932 pp. Prentice-Hall, Inc. Reviewed in *Abrasive Ind.*, **14** [3], 23 (1933).—The economic significance of a group of leading American industries is discussed in this volume. E.P.R.

General Engineering Handbook. ANON. Edited by C. E. O'Rourke and others. McGraw-Hill Book Co., New York, 1932. 921 pp. *Mech. Eng.*, **54** [7], 522 (1932). F.G.H.

Notice of official changes in active list of permissible explosives and blasting devices approved prior to Jan. 31, 1933. ANON. Bur. Mines *Rept. of Invest.*, No. 3202. Free. R.A.H.

Cut-and-fill stoping. C. H. JOHNSON AND E. D. GARDNER. Bur. Mines *Information Circ.*, No. 6688. 58 pp. Free. The report discusses the use of the cut-and-fill method of mining and touches upon its modifications and combinations. R.A.H.

Growth and development of nonmetallic mineral industries. OLIVER BOWLES AND C. W. JUSTICE. Bur. Mines *Information Circ.*, No. 6687, 50 pp. Free. A statistical history is given of the nonmetallic industries, touching upon their growth and classification, the industrial demand for their products, and relation of certain nonmetals to the construction industries. R.A.H.

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A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific, and Art Questions, and Promotion of Coöperative Research

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Vol. 12 **June, 1933** **No. 6**

EDITORIALS

TRIBUTE TO BOOTHE COLWELL DAVIS

A Constructive Leader in Ceramics

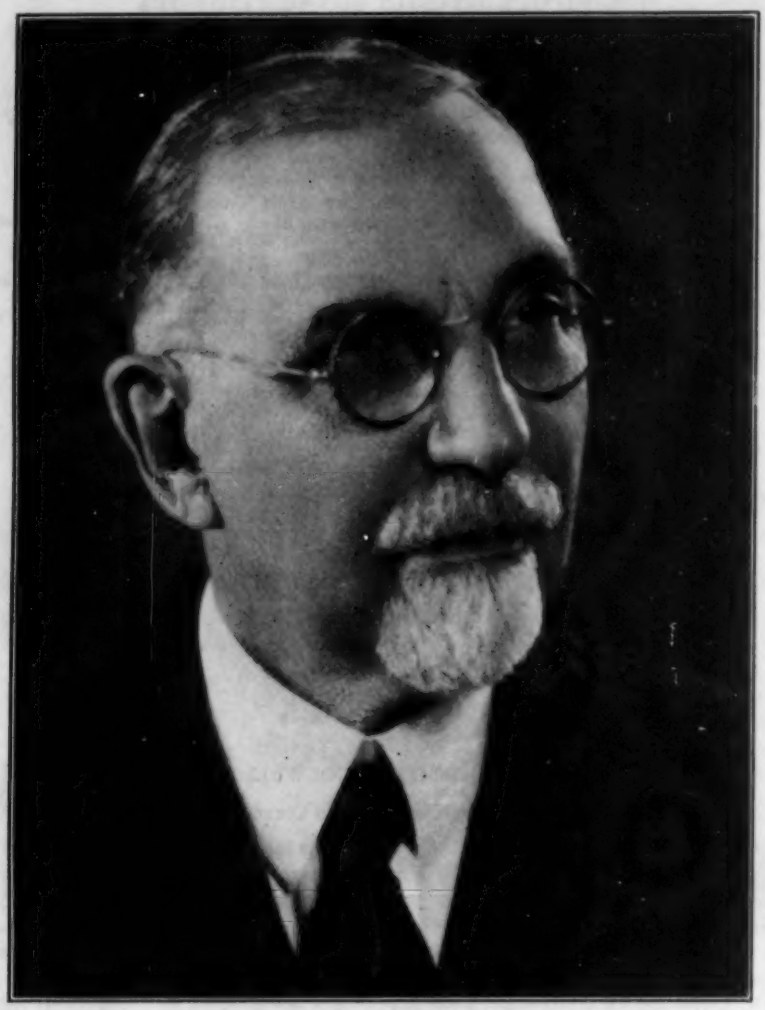
Difficult indeed is it to trace and to measure our indebtedness to those who are indirectly responsible for our individual happiness and welfare. We justly credit ourselves most largely for our individual accomplishments and acquisitions but in doing so we are prone to overlook our indebtedness to others. Every ceramist owes a large debt to Boothe C. Davis, President of Alfred University and of the New York State College of Ceramics.

Dr. Davis has for thirty-eight years gone about his business as President at Alfred with the sole purpose of giving a successful administration.

His direct interest was Alfred University but he correctly conceived that to accomplish the most for Alfred he had to do more than simply to administer its affairs and husband its resources; his conception of his task included increasing the usefulness of Alfred University.

When "Jake" Merrill and Charles Harris, operators of a roofing tile plant at Alfred Center, drew to the attention of Dr. Davis that New York State should have a collegiate course in ceramic technology, Dr. Davis promptly took leadership in formulating plans, securing political support, and obtaining the necessary legislative actions. Not content

with having a ceramic department only, he councilled and secured support for a college of ceramics, for lifting the instruction from the empirical to fundamental, and for broadening the curriculum to cover the entire range of ceramic arts and science.



BOOTHE C. DAVIS

On June 12 they will dedicate at Alfred their third and largest building erected and equipped for ceramic education and research.

On June 12 Dr. Boothe C. Davis retires after having served for thirty-three years as President of the New York State College of Ceramics. More than a dedication of buildings and more than making determinations for pressing on even to greater things in and for ceramics at Alfred this celebration will be an acknowledgment of appreciation of service contributions by Dr. Davis to ceramic arts and science.

Dr. Boothe C. Davis entered upon his duties as President of Alfred University at thirty-two years of age, September 1, 1895, and has remained in this position continuously for thirty-eight years.

His presidency of the New York State College of Ceramics at Alfred University has continued since its establishment in 1900. At that time Theodore Roosevelt was Governor of New York State. Through the efforts of President Davis, J. J. Merrill, the late Judge P. B. McLennan, and other friends of Alfred, the attention of the Governor was called to the fact that Ohio had established a school of ceramics, and that New York should be the second state in the Union to establish such a school, as New York has a wide variety of ceramic industries and furnishes the greatest market in the country for ceramic products.

After much effort a law was passed in 1900 and signed by the then Governor Roosevelt, establishing the School. President Davis became its first and only president for the third of a century of its history.

President Davis' first service for the school was the selection of Charles F. Binns as the first Director of the School. Doctor Binns' service as Director for over thirty years brought the school to distinction as a school of technology and art in the field of ceramics. But President Davis, through his influence with governors, legislatures, and the State Education Department, saw to it that annual appropriations were obtained, new equipment added, new buildings provided, and the faculty strengthened to keep pace with the growing demands.

The appropriation of $175,000 for the new Ceramic College building, granted by the Legislature of 1930 and approved by Governor Franklin D. Roosevelt; the elevation of the School to the rank of a college by the Legislature of 1932, and its approval also by Governor Roosevelt, with appropriations for equipment and a new staff member; appropriations for further equipment and a new staff member by the Legislature of 1933, with the approval of Governor Lehman, have all been achievements in which President Davis' guiding hand and genius have been manifest.

These, with the appointments of Dr. Major E. Holmes as Dean of the College, and Dr. Samuel R. Scholes as Director of the new Glass Laboratory of the College, the first such glass laboratory in the country, constitute a fitting climax for a record of thirty-three years in executive service in the interest of ceramic education.

Dr. Boothe C. Davis has builded a ceramic educational and research institution that will, to an increasing extent, contribute largely to the advancement of ceramic science, technology, and art. The impetus and the direction which he has given to academic ceramics during the past thirty-three years have advanced and will continue to benefit the welfare of each ceramic person and plant. The least we can do is to tell Dr. Davis of our sincerely felt indebtedness and appreciation. This opportunity to tell him of our regard will be June 12 at Alfred University.

We regret that the laws of New York State require that Dr. Davis retire from active to emeritus presidency at Alfred. We wish him many years of happy contemplation of his successes and a realization that he has builded solidly a ceramic institution that will continue to serve for many generations.

SELL AMERICAN-MADE WARE

This Society is more interested in "SELL AMERICANS" than in "BUY AMERICAN." We believe that American citizens should demand those American-made goods, the foreign equivalent of which does not better serve or more aesthetically appeal. To the extent of correcting the foolish notion that there are intrinsic or aesthetic values in

foreign-made ware not possessed by home-made goods, we believe in supporting the "BUY AMERICAN" movement.

Furthermore, we believe that the United States Government should give the American industries that prompt protection which other countries give their industries by embargoes and penalties. The Government should also impose a tariff based on differences in wage scales and currency values.

The American citizens and the American Government should realize that the economic welfare of American citizens generally and of the American citizen individually depends upon the welfare of the industries and upon agriculture. An investment in American-made goods is an investment which will bring personal gains. America can not maintain her high wage standards unless Americans patronize their home industries and unless the Government gives the protection to the American industries equivalent to the protection which other countries are giving to their industries. In this, however, we need not be provincial, need not deprive ourselves of the fine things produced abroad, or attempt the uneconomic boycott of foreign materials the equivalent of which in quality or use is not produced in America.

"BUY AMERICAN," however, is only one portion of the problem, and the much lesser one. We believe that each individual and each manufacturing concern must in the most effective manner sell its services and its products. The demands for personal services and for manufactured products can result only from convincing efforts of those who have services and products for sale. We believe it more important to "SELL AMERICANS" than to depend upon results from "BUY AMERICAN" activities.

The United States Potters Association is to be commended upon sending a dramatic exhibit to the principal cities of the country. This it has done in coöperation with the Operative Potters. These dramatic exhibits of pottery making have created a great deal of interest in American-made pottery, much more so than would any strictly "BUY AMERICAN" campaign.

The initiative here was by the potters and the pottery operators. The Fulper Pottery Company has a similar dramatic exhibit showing its pottery-making methods and its products. These exhibits will be effective in making the purchasing public conscious of the high merits of the Fulper artware.

This Society has collaborated with the vitrified china manufacturers in efforts to sell American-made vitrified china to hotels, to railroads, and to other large users of these products. We are glad to report assurances from several railroads and hotels which previously used foreign-made china exclusively that they are placing and in the future will place their orders with American manufacturers. Their decisions were based upon comparative quality and on the economic benefits of patronizing home industries. The Netherland Plaza Hotel of Cincinnati, the Hotel Sherman of Chicago, the New Yorker Hotel of New York, the Book-Cadillac of Detroit, and other heretofore exclusive users of foreign china are now placing orders for American-made china.

At the Century of Progress Exposition the following concessions have been sold on the economic value of purchasing American-made china. They are as follows:

Toy Town Tavern, Enchanted Island	Shenango China
Sears-Roebuck Building, B/G Sandwich Shops	Shenango China
Stewart-Ashby Coffee Company (40 Coffee Stands)	Shenango China
Field's Museum Cafeteria	Shenango China
College Inn (Hotel Sherman Company)	Fraunfelter China
Executives Dining Room, Administration Building	Onondaga China
Century Club (where President Roosevelt will be entertained)	Onondaga China
Restaurant of Swift and Company	Onondaga China
Hellman Blue Ribbon Restaurant	Mayer China Co.
Maggi Sauces	Mayer China Co.
Adobe House	Bailey-Walker China Co.

In addition, we have been informed that American china will be used in the "Old Vienna" concession at the Exposition.

That American-made hotel chinaware merits consideration by our hotels, railroads, hospitals, and other users of vitrified china is shown by tests made at the United States Bureau of Standards.

"Tests made on a limited variety of ware by the Bureau of Standards, Washington, D. C., show that hotel china, vitreous china, and earthenware for household use made in America are better able to withstand sudden blows than ware made in foreign countries—France, Germany, and England, in the case of hotel china, and France, Germany, and Japan in the case of vitreous china and earthenware. American ware also was found to withstand crazing and cracking under sudden temperature change much better than foreign-made ware.

"A brief report on the tests which were not yet completed, was made by the Bureau in *Technical News Bulletin*, No. 59, issued in March 9, 1922, under the heading 'Specifications for China Tableware.' The report reads as follows:

" 'Based simply upon the work done by the Bureau of Standards, which necessarily covers only a limited variety of ware, it would appear that domestic hotel china is very much superior to the French, German, and English in ability to withstand sudden blows, as indicated by impact tests. In this respect, also, the American vitreous china and earthenware for household use are also much superior to the French, German, and Japanese ware upon which tests have been carried out.

" 'In regard to crazing and cracking from sudden temperature change, the American hotel ware did not craze and only cracked at the highest temperatures employed. The English ware crazed easily, but did not crack, while the French and German ware did not craze but cracked at the lower temperatures used in the test. The American earthenware, with some exceptions, did not craze during the standard test, but crazed at the higher temperatures which were employed for comparison. Although the French, German, and Japanese household ware did not craze, they fractured from sudden thermal shock.

" 'It has been found that the design of the rolled edge and the angle of inclination of the rim of hotel plates has as much effect on the ability to withstand chipping as the properties of the body from which the plate is made. The glazes now in use appear to be sufficiently well constituted chemically to withstand the alkaline solutions used in dish washing.' "

The American Telephone and Telegraph Company made tests of American-made china on its own initiative and, as reported in the *Ceramic Industry* of October, 1925, issue, their decision was that American-made china was superior, and therefore all of the concessions of the American Telephone and Telegraph Company are now using American-made china.

These are arguments used and the results obtained in our "Sell American-Made Products" campaign.

PAPERS AND DISCUSSIONS

RESULTS OF TESTS ON SEVEN DEMONSTRATION STRUCTURES WITH SUMMARY COVERING TESTS ON TWENTY STRUCTURES*

Report No. 8 of Committee on Reinforced Brick Masonry

Foreword

Report No. 2 of the Committee covered the tests of three reinforced brick masonry demonstration structures, Report No. 4 ten additional tests, and the present report gives the results of seven further tests together with a summary of the tests of all twenty structures. Some computed values are given based on certain assumptions useful chiefly in obtaining comparative values. The design and specifications under which these twenty structures were built are given in Report No. 1. The general method of conducting tests was given in Report No. 3.

Throughout the reports live loads only are considered except where noted. Some slight variations exist in actual dimensions of beams and slabs measured in the field. The recorded unit loads and stresses have been corrected for this and represent net live loads per square foot and corresponding bending moments. Deflections were read to $^1/_{16}$ inch on both sides of each member and averaged. Unless otherwise noted, deflections are in $^1/_{16}$ inch.

The tests as a whole were very satisfactory and gave desirable information. Workmanship, which has been considered a likely source of weakness, seems to be less important than a satisfactory selection of mortar materials. No very soft brick were used, but in no case was the strength of the brick an apparent source of weakness. Where adequate mortar was used both brick and steel were stressed to unusually high values. In no case did any brick fall from the beams or slabs before failure. The four beams from Tests XVI and XVII were removed to the laboratory of the Ohio State University Engineering Experiment Station and loaded in a testing machine. Results of these tests are given in Part III of this report.

There were five additional structures built but not yet tested.

Brick, similar to those used in seventeen of the structures, have been tested for physical properties and strength of brick and mortar in adhesion and shear. This work has been under way for the past ten months at the Rensselaer Polytechnic Institute by H. Duff Williamson under the direction of Professor T. R. Lawson. A complete report of these tests will be available shortly. Preliminary results of the tests of physical properties of the brick are given in Part III of this report.

The data obtained from the tests of twenty demonstration structures set a definite standard for performance. Through the construction of similar structures an opportunity is afforded to demonstrate easily the adaptability of any particular brick and mortar combination.

Part I of this report covers tests of seven reinforced brick masonry demonstration structures, Part II a summary of tests of twenty such structures, and Part III preliminary results of tests of the brick used in seventeen of the above structures and a special report on testing four beams from Tests XVI and XVII.

Respectfully submitted on behalf of the Committee,

EDW. E. KRAUSS, *Chairman*
JUDSON VOGDES, *Secretary*

February 1, 1933.

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* Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Pittsburgh, Pa., February, 1933 (National Brick Manufacturers Research Foundation and the Structural Clay Products Division of the American Ceramic Society). Received January 17, 1933.

Part I. Tests of Reinforced Brick Masonry Demonstration Structures

Test XIV. Washington Structure No. 3

Considering the extra large loads carried by the two preceding Washington structures,[1] it was decided to erect two new ones and to test them during the 1932 Annual Meeting of the American Ceramic Society. Those witnessing the test will remember the phenomenal behavior of these structures.

The first of this series, structure No. 3, was built with the same kind of brick as structures Nos. 1 and 2, Tests XI and XII, using 1–1–6 cement-lime mortar. The design and reinforcing were identical with the first two structures.

After standing for fifty-six days this structure was loaded in the usual manner. The first sign of failure was evidenced by a crack across the top of the slab over the north beam, under a load of 748 lb. per sq. ft. on the center slab. Under a corresponding load of 880 lb. per sq. ft. the beams lifted from the outside of the piers with no other sign of cracking. With a load of 1320 lb. per sq. ft. live load on the center slab, the soldier beam failed slowly and settled to the safety piers. Figure 1 shows this structure after the beam had been jacked into position and loading continued until the slab failed. This occurred on the completion of the cantilever load of 1320 lb. per sq. ft. Probably failure in the slab was accelerated by the settlement of the soldier beam which produced some torsion in the slab. In spite of the fact that settlement of the soldier beam caused the slab to rest on two of the safety piers, the load remained steady, indicating in some measure how gradual the failure was.

The soldier beam failed under a live load of 14,430 lb. and produced a computed stress in the reinforcement of 61,500 lb. per sq. in. which is close to the yield point. The stress in the reinforcement of the running bond beam at this time was computed as 67,500 lb. per sq. in., indicating that some of the tensile stress was carried by the masonry.

The compressive stress computed for the brick masonry was 945 lb. per sq. in. for the running bond beam and 1157 lb. per sq. in. for the soldier beam. These stresses were well above the usually accepted working stress for brick masonry and still there was no sign of failure in compression. The shearing stresses were low, the maximum being 66 lb. per sq. in. for the soldier beam. Figure 2 shows a beam after failure indicating the condition of the masonry. Failure seems to have occurred by overstressing the steel. The computed bond stresses of 150 and 187 lb. per sq. in. for the running bond and soldier beams, respectively, are well above the usual allowable working stresses for deformed bars.

The slab in the structure did not fail until after one beam had settled. After jacking the beam, slab, and load to their original positions, 44 lb. per sq. ft. were added to the cantilever load (2 layers) when the slab failed. This record is remarkable, since the unit stress at the time of the beam failure approached the limiting stress. The unit shear at failure is figured at 153 lb. per sq. in. which is higher than previously found for similar slabs. Comparing this test with the one made previously of the same design and materials, the increase in strength shown here can be credited to superior

[1] See Report No. 4, *Jour. Amer. Ceram. Soc.*, **15** [5], 273 (1932).

workmanship. An examination of the previous Washington structures after loading showed that the reinforcing was not completely covered with mortar. Correcting this deficiency increased the load-carrying capacity about 30%.

Figure 1 shows structures of Tests XIV and XV under maximum load, with the former on the left. A live load of 440 lb. per sq. ft. was allowed to remain on the structures twenty-four hours with no apparent increase in deflection in either beams or slabs. The limiting deflection for plastered ceilings was not reached until a live load of 968 lb. per sq. ft. was placed on the center slab. Table I gives the complete data for the test. Trans-

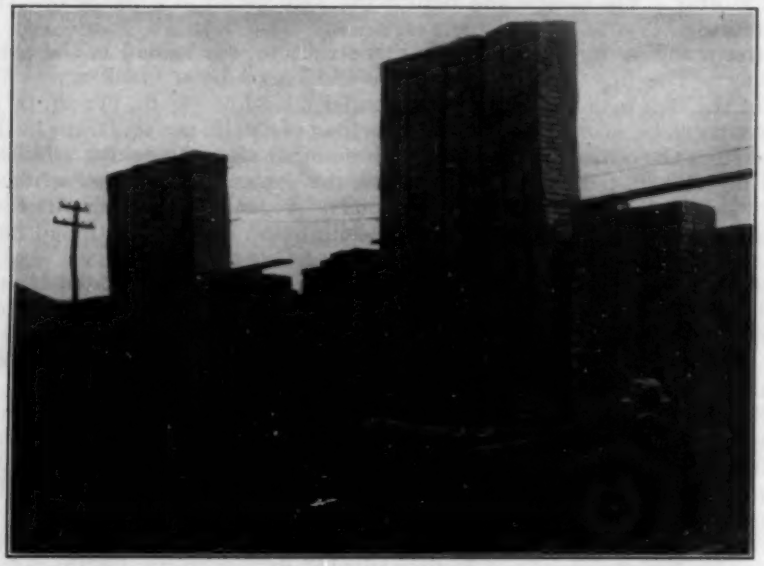


FIG. 1.—Washington structures Nos. 3 and 4 at failure with live loads of 1320 and 1408 lb. per sq. ft., respectively. (The brick live load is piled about 12 ft. high.)

verse cracks occurred on the top of the slab across the supporting beams, the first of which appeared with a live load of 792 lb. per sq. ft.

Test XV. Washington Structure No. 4

This structure was built with structure No. 3 and was identical, with the exception that both beams were of running bond. Different masons did the actual bricklaying. Test was made at the age of fifty-four days before a group of engineers, architects, builders, and manufacturers, as part of the Annual Meeting of the Society, February 11, 1932.

The load was applied as in previous tests. A live load of 528 lb. per sq. ft. on the center slab was applied and allowed to remain for twenty-four hours. No increase in deflection was apparent in either beams or slab. Under a load of 1408 lb. per sq. ft. on the center slab one of the beams failed, settling slowly to the safety piers. This was followed shortly with no

increase in load by the slab. The load remained in position, which is evidence of the gradual failing as the load piers were 64 brick high (about 12 ft.). It is a reasonable assumption that the impact and torsion produced in the slab by the settling of the beam contributed to the failure of the slab.

The maximum load on the beams was 15,400 lb., the largest load carried by any structure thus far. The computed stress in the reinforcing for the load was 71,800 lb. per sq. in., which is very high. Cracks first appeared in the beams under a live load of 1144 lb. per sq. ft. The deflection increased rapidly to failure. Apparently the masonry was taking some of the tensile stresses. The computed compressive stress of 1008 lb. per sq. in. is

FIG. 2.—Running bond beam showing shear failure.

higher than usually recommended for brick masonry in cement mortar. No indication of compression failure was observed. The unit shearing stress was 62 lb. per sq. in. Under full load the deflection was about the limit for plastered ceilings. The capacity of the beams was apparently limited by the strength of the reinforcing which was fully developed. This is important since the bond stress was 160 lb. per sq. in. These beams are a splendid example of the strength that can be obtained with suitable materials and workmanship.

The live load of 1408 lb. per sq. ft. on the center slab, amounting to a total of 20,530 lb., is the maximum carried by any structure in this series. Using the previous assumptions, the computed tensile stress in the steel amounted to 63,000 lb. per sq. in. The maximum compressive stress in the slab was 4080 lb. per sq. in. with no sign of crushing. Considering the unit shearing stress of 163 lb. per sq. in. this structure demonstrates the possibilities of reinforced brick masonry. Under a live load of 880 lb. per

TABLE I

TEST XIV. WASHINGTON STRUCTURE NO. 3

(Mortar 1:1:6 hydrated lime. Built December 17, 1931; tested February 11, 1932; age 56 days)

Loads and bending moments								Deflections (in.)		
Center span				End span				Center slab	Running bond beam	Soldier bond beam
Layers	Total live load	Unit live load	B.M.	Layers	Total live load	Unit live load	B.M.	Av.	Av.	Av.
4	1283	88	8250	2	321	44	8350	0	0	0
8	2566	176	16800	4	642	88	16700	0.013	0	0.013
12	3849	264	25150	6	963	132	25000	.038	0.015	.025
16	5132	352	33500	8	1284	176	33400	.055	.015	.025
20*	6415	440	41400	10	1605	220	41700	.088	.025	.025
20	6415	440	41400	10	1605	220	41700	.088	.038	.025
24	7698	528	49900	12	1926	264	50000	.011	.038	.025
28	8981	616	58000	14	2247	308	58600	.014	.005	.045
32	10264	704	67000	16	2568	352	67000	.017	.005	.060
36	11547	792	75500	18	2889	396	75300	.019	.005	.075[a]
40	12830	880	83500	20	3210	440	83500	.022	.007	.080[b]
44	14113	968	91500	22	3531	484	91700	.026	.011	.105
48	15396	1056	100500	24	3852	528	100000	.029	.012	.125
52	16679	1144	109000	26	4173	572	108500	.034	.016	.135
56	17962	1232	117000	28	4494	616	116700	.037	.018	.175
60	19245	1320			4494	616				[c]
60	19245	1320	125000	30	4815	660	125000	.058	.028	[d]

[a] With 34 courses on center slab, crack appeared in top of slab over north beam.
[b] Beams lifted from piers at outer face.
[c] Soldier beam failed, resting on dry piers.
[d] Slab failed, probably due to settlement of beam.
* Twenty layers placed February 10 and allowed to remain overnight.

TABLE II

TEST XV. WASHINGTON STRUCTURE NO. 4

(Mortar 1:1:6 hydrated lime. Built December 19, 1931; tested February 11, 1932; age 54 days)

Loads and bending moments								Deflections (in.)		
Center span				End span						
Layers	Total live load	Unit live load	B.M.	Layers	Total live load	Unit live load	B.M.	Center slab Av.	Running bond beam Av.	Soldier bond beam Av.
0	0	0	0	0	0	0	0	0	0	0
4	1283	88	8250	2	321	44	8350	0	0	0
8	2566	176	16800	4	642	88	16700	0.025	0	0.013
12	3849	264	25150	6	963	132	25000	.038	0	.013
16	5132	352	33500	8	1284	176	33400	.75	0	.013
20	6415	440	41400	10	1605	220	41700	.10	0.01	.038
24*	7698	528	49900	12	1926	264	50000	.113	.01	.038
24	7698	528	49900	12	1926	264	50000	.113	.01	.038
28	8981	616	58000	14	2247	308	58600	.15	.018	.055
32	10264	704	67000	16	2568	352	67000	.17	.05	.05
36	11547	792	75500	18	2889	396	75300	.20	.073	.10
40	12830	880	83500	20	3210	440	83500	.25	.10	.10[a, b, c]
44	14113	968	91500	22	3531	484	91700	.28	.11	.15
48	15396	1056	100500	24	3852	528	100000	.31	.15	.18
52	16679	1144	109000	26	4173	572	108500	.36	.17	.20[d]
56	17962	1232	117000	28	4494	616	116700	.41	.25	.25
60	19245	1320	125000	30	4815	660	125000	.46	.28	.29[e]
64	20528	1408	134000	32	5136	704	133500			[f]

[a] With 38 courses on center, crack appeared in bottom of center slab (in joint); also crack in top of slab over both beams.
[b] Crack appeared in bottom of both beams near center.
[c] Beams lifted from piers showing crack at outer face of pier.
[d] Definite diagonal shear crack north side of south beam.
[e] North beam failed apparently in shear (still carrying load).
[f] North beam failed completely; slab failed immediately following torsion and impact.
* Twenty-four layers placed February 10 and allowed to remain overnight.

sq. ft. on the center slab the deflection was equal to the maximum for plastered ceilings. The first cracks appeared with this load in the center of the under side of the slab and in the top over the supporting beams. The performance of the slab indicates that the full value of the reinforcing steel was developed without sign of failure in the masonry. This is the fourth Washington slab to be built under this design and justifies a conclusion that such slabs conservatively carry more live load than would be permitted under existing design methods and unit stresses.

Figure 1 shows Tests XIV and XV under maximum load, with the latter on the right. Table II gives complete data for the test.

Test XVI. Columbus Structure No. 1

This structure was one of two built at the plant of the Claycraft Brick Company, Columbus, Ohio. Construction was in accordance with the

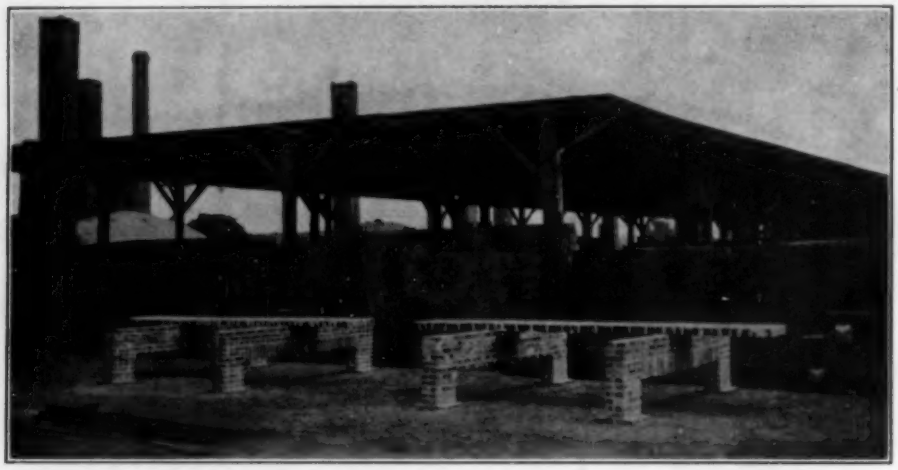


FIG. 3.—Columbus structures Nos. 1 and 2 before loading.

plans and specifications of the Committee. The brick used were stiff-mud side-cut having a very low absorption of about 2%. The structures were built January 14 and 15, 1932, and tested July 14 of the same year (Fig. 3). Reinforcing was plain, round, soft steel having an elastic limit of 43,000 lb. per sq. in.

Dry brick piers were placed on the slab up to a live load of 209 lb. per sq. ft. over the entire slab. This load was allowed to stand overnight and the deflection noted. No increase occurred for this condition. The following day loading was continued until there was a total live load of 601 lb. per sq. ft. at which time the dry brick piers began to weave and finally fell, breaking one of the cantilever slabs. Following this the remaining cantilever was loaded with a corresponding load on the center slab. Under a load of 655 lb. per sq. ft. this cantilever failed. The center slab, acting as a simple slab, was loaded to 516 lb. per sq. ft. when it failed.

There was no evidence of failure in bond. In each case failure was ap-

TABLE III

TEST XVI. COLUMBUS STRUCTURE, NO. 1

(Mortar 1:1:6 hydrated lime. Built January 14, 1932; tested July 14, 1932; age 184 days)

Loads and bending moments								Deflections (in.)		
Center span				End span				Center slab	Running bond beam	Soldier bond beam
Layers	Total live load	Unit live load	B.M.	Layers	Total live load	Unit live load	B.M.	Av.	Av.	Av.
0										
2	555	34.8	0	2	278	34.8	6670	0.008		0.001
4	1110	69.5	0	4	555	69.5	13300	.008		.003
6	1665	103.2	0	6	834	103.2	20000	.016		.006
8	2220	139	0	8	1112	139	25800	.016	0.016	.012
10	2775	174	0	10	1390	174	33400	.016	.019	.019
12	3330	209	0	12	1668	209	40000	.016	.019	.025
14				14						
16	4440	271	0	16	2224	278	54800	.023	.033	.032
18				18						
20	5550	351	0	20	2780	351	66700	.031	.043	.046
22				22						
24	6660	417	0	24	3336	417	80600	.039		.109
26				26						
28	7770	487	0	28	3895	487	93500	.086		
30				30						
32	8900	556	0	32	4450	556	107000			

parently due to over-stressing the steel. Table III gives the data on loading and corresponding deflections.

A study of the results shows that this slab carried a very high load. The load condition produced by 655 lb. per sq. ft. on the cantilever corresponds to a load on the center slab of 1310 lb. per sq. ft. for the specified condition of loading, considering the bending stresses. The load of 516 lb. per sq. ft. on the center slab acting as a simple slab corresponds to a load of 1032 lb. per sq. ft. on the usual continuous slab.

Following the slab test the beams, which showed no sign of failure under the load, were removed to the laboratory of the Engineering Experiment Station of the Ohio State University and tested. Results of these tests are given in Part III of this report. Considering the results of the field and

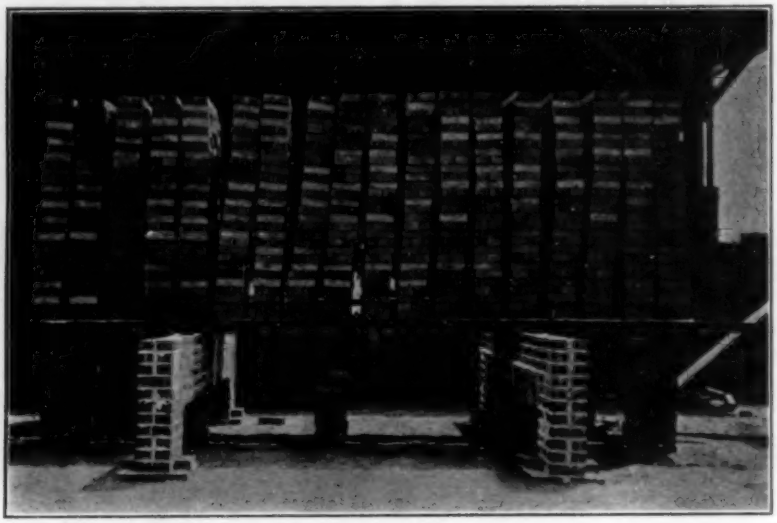


FIG. 4.—Columbus structure No. 2 under a load of 601 lb. per sq. ft.

laboratory tests these structures indicate desirable performance. Figure 4 shows the structure under full load.

Test XVII. Columbus Structure No. 2

This structure was the second one built at the plant of the Claycraft Brick Company at Columbus, Ohio. The structure was built January 15 with stiff-mud, side-cut shale brick, having an absorption of about 8%, and tested July 14, 1932. The reinforcing was plain, round, soft steel having an elastic limit of 43,000 lb. per sq. in.

Load was applied to the structure in the form of dry brick piers. Table IV gives the loads with corresponding deflections.

A uniform live load of 209 lb. per sq. ft. was placed over the entire structure, center and cantilever alike. This load was allowed to stand overnight when no sign of increase in deflection was observed. Unfortunately during the loading of the adjoining structure at this time its load fell over

TABLE IV

TEST XVII. COLUMBUS STRUCTURE NO. 2

(Mortar 1:1:6 hydrated lime. Beam and slab built January 14, 1932; tested July 14, 1932; age 184 days)

Loads and bending moments								Deflections (in.)		
Center span				End span				Center slab	Running bond beam	Soldier bond beam
Layers	Total live load	Unit live load	B.M.	Layers	Total live load	Unit live load	B.M.	Av.	Av.	Av.
1	302	18.4	0	1	151	18.4	7250	0.008	0.001	0.001
2	605	36.7	0	2	302	36.7	14500	.008	.001	.001
4	1210	73.4	0	4	605	73.4	29000	.016	.003	.003
6	1815	110.2	0	6	908	110.2	43500	.023	.008	.005
8	2420	146.8	0	8	1210	146.8	58000	.023	.013	.007
10	3025	183.7	0	10	1522	183.7	72500	.023	.019	.009
12	3630	220.4	0	12	1815	220.4	87000	.023	.031	.010
12	3630	220.4	0	12	1815	220.4	87000	.025		
12	3630	220.4	0	12	1815	220.4	87000	.030		

TABLE V

TEST XVIII. BALTIMORE STRUCTURE NO. 2

(Mortar 1:1:6 hydrated lime. Beams and slabs built January 12, 1932; tested May 5, 1932; age 114 days)

Loads and bending moments								Deflections (in.)		
Center span				End span				Slab	Running bond beam	Soldier bond beam
Layers	Total live load	Unit load	B.M.	Layers	Total live load	Unit load	B.M.	Av.	Av.	Av.
0	0									
2	605	39	3636	1	151	20	3636	0.1	0	0
4	1210	78	7260	2	302	39	7260	0.4	0	0
6	1815	117	10890	3	453	58	10890	0.6	0	0
8	2420	156	14520	4	604	78	14520	0.8	0	0
10	3025	195	18150	5	755	98	18150	1	0	0.1
12	3630	234	21780	6	906	117	21780	1.3	0	.15
14	4235	273	25410	7	1057	137	25410	1.7	0.05	.15
16	4840	312	29040	8	1208	156	29040	2.3	.05	.25
18	5445	351	32670	9	1359	176	32670	2.95	.05	.35
20	6050	390	36300	10	1510	195	36300	3.25	.1	.4
22	6655	429	39930	11	1661	215	39930	4.6	.3	.5
24	7260	468	43560	12	1812	234	43560	6	.5	.75

and damaged this structure making it impossible to continue the test as designed.

The undamaged cantilever was further loaded to a live load of 676 lb. per sq. ft. uniformly distributed, which produced failure. Comparing the deflection of this structure with Test XVI, the cantilever deflections are less for Test XVII. This means a higher modulus of elasticity for the slab as a whole.

The beams showed no evidence of failure under this loading and were later tested in the laboratory of the Ohio State University Engineering Experiment Station. For details of this test see Part III of this report.

It is unfortunate that the toppling of the load on one structure so quickly terminated the slab test. The load of 676 lb. per sq. ft. on the cantilever

FIG. 5.—Baltimore structure No. 2 at failure; load 468 lb. per sq. ft.

would correspond to a live load of 1352 lb. per sq. ft. on the center slab for the usual method of loading. Since the usual type of failure occurs with a cracking over the supporting beams indicating a failure in the cantilever slab, it is a safe deduction to assume that the slab would have been among the best reported.

Test XVIII. Baltimore Structure No. 2

This structure was built at the plant of the Champion Brick Company, Baltimore, Md., January 12, 1932, and tested May 5, 1932. The brick used were stiff-mud, side-cut with a compressive strength of 6800 lb. per sq. in. and an absorption of 7%. Mortar consisted of one part Portland cement, one part hydrated lime, and six parts sand. The reinforcing consisted of deformed steel. A later inspection of the sand used indicated a high percentage of clay or loam similar to that found in bank (unwashed) sand.

Load was applied in the prescribed manner, using dry brick piers. Un-

der a live load of 468 lb. per sq. ft. on the center slab failure occurred over the supporting beams. In this case the brick did not fail in tension and instead a shearing of the joints was observed. In spite of apparent weakness in the mortar joints the load required to produce the limiting deflection was over 400 lb. per sq. ft. Table V gives data on loading and deflections.

The beam showed no sign of failure under the total load. Deflections in the beams were normal. In spite of the fact that the mortar in this structure was apparently weak the load carried both by beams and slab indicated some usefulness. The reinforcing in each case was stressed above the usual working stress of 20,000 lb. per sq. in.

This test shows plainly how a good brick laid with poor mortar sacrifices its natural advantages. Quality of sand in reinforced brick masonry as in

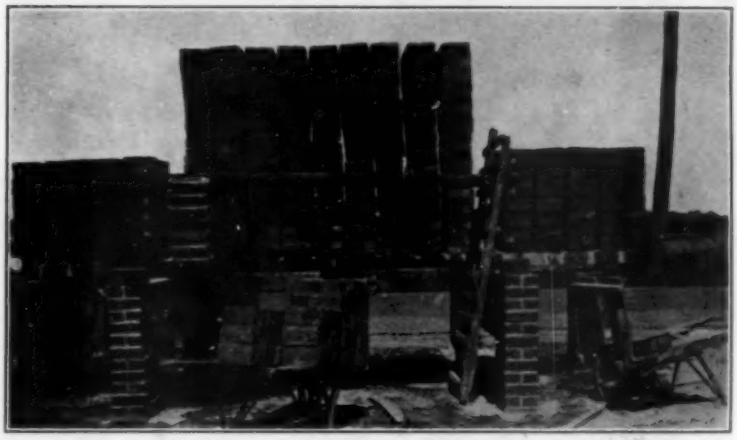


FIG. 6.—Chester, Pa., structure carrying a load of 429 lb. per sq. ft.

reinforced concrete is a very important item and must be carefully considered. Figure 5 shows the structure under full load.

Test XIX. Chester, Pa., Structure

This structure was built at the plant of the McClaskey Brick Co., Chester, Pa., May 22, and tested June 23, 1932. The brick used were soft-mud having a compressive strength of 9400 lb. per sq. in. and an absorption of 12%. The mortar consisted of one part Portland cement, one part hydrated lime, and six parts clean washed sand. The reinforcing was plain, round, mild steel. The brick were slightly wetted before laying.

Load was applied in the prescribed manner using dry brick piers. The first sign of cracking occurred under a live load of 396 lb. per sq. ft. where the soldier beam cracked. Under a live load of 495 lb. per sq. ft. this beam failed, followed immediately by a crack across the top of the slab over this supporting beam. Figure 6 shows the structure under a load of 429 lb. per sq. ft.

Failure occurred rather suddenly without warning. The deflections up to the maximum load were not excessive. The limiting deflection was

not reached either in beam or slab. The bars in the soldier beam slipped in the mortar at failure.

Probably the failure of the slab was accelerated by the sudden failure of the soldier beam. Table VI gives data on loads and deflections.

In this test materials and workmanship were apparently satisfactory. There was no evidence of unfilled joints. The brick used were taken directly from the kiln and were very dry. Wetting was provided by sprinkling in the pile before laying. The presence of kiln dust and dry sand on the surface of the brick probably contributed much to the deficiency of the mortar joints. An inspection of individual brick after the test showed very

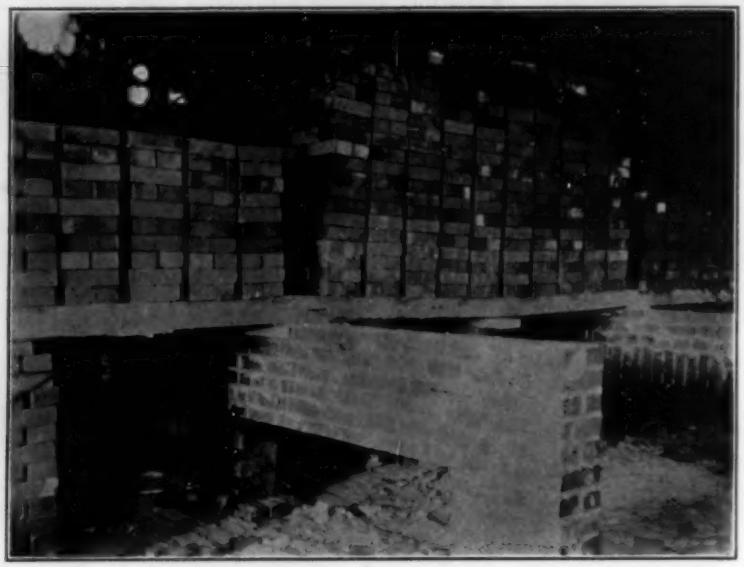


FIG. 7.—Watsontown structure with load of 350 lb. per sq. ft.

little adhesion between brick and mortar where there was an excess of dust and sand on the surface of the brick. This is a factor that will bear further investigation.

Test XX. Watsontown Structure

This structure was built at the plant of the Keystone Brick Co., Watsontown, Pa., October 26, 1932, under the direction of Walter Parsons. The brick used were stiff-mud side-cut with three holes, having an absorption of about 10%. The mortar consisted of one part Portland cement, one part hydrated lime, and six parts washed sand. Reinforcing bars were plain, round, mild steel.

Testing was carried out in the prescribed manner. Under a live load of 350 lb. per sq. ft. on the center slab, the slab failed by cracking across the top over each supporting beam and in the underside at the center. No sign of failure occurred in either beam. The deflection at no time exceeded

TABLE VI. TEST XIX. CHESTER, PA., STRUCTURE

(Mortar 1:1:6 lump lime. Beams and slab built May 22, 1932; tested June 23, 1932)

Loads and bending moments								Deflections (in.)		
Center span				End span				Slab	Running bond beam	Soldier bond beam
Layers	Total live load	Unit load	B.M.	Layers	Total live load	Unit load	B.M.	Av.	Av.	Av.
0										
2	524	33.0	3144	1	131	16.1	3144	0	0	0
4	1048	66.0	6288	2	232	32.0	6288	0	0	0
6	1572	99	9432	3	363	48	9432	0.25	0	0
8	2096	132	12576	4	494	64	12576	.25	0	0
10	2620	165	15720	5	625	80	15720	.25	0	0
12	3144	198	18864	6	756	96	18864	.65	0	0
14	3668	231	22008	7	887	112	22008	1.0	0	0
16	4192	264	25152	8	1018	128	25152	1.5	0	0.5
18	4716	297	28296	9	1149	144	28296	1.75	0.13	.5
20	5240	330	31440	10	1280	160	31440	2.0	.25	.5
22	5764	363	34584	11	1411	176	34584	2.0	.25	.5
24	6288	396	37728	12	1542	192	37728	2.25	.25	.5
26	6812	429	40872	13	1673	208	40872	2.75	.25	.5
28	7336	462	44016	14	1804	224	44016	2.88	.25	.25
30	7860	495	47160	15	1935	240	47160			

TABLE VII. TEST XX. WATSONTOWN, PA., STRUCTURE

(Beams and slab built October 26, 1932; tested November 25, 1932; age 30 days)

0										
2	564	35	3384	1	141	17	3384	0	0	0
4	1128	70	6768	2	282	34	6768	0	0	0
6	1692	105	10152	3	423	51	10152	0.5	0	0
8	2256	140	13536	4	564	68	13536	1.0	0	0
10	2820	175	16920	5	705	85	16920	1.0	0	0
12	3384	210	20304	6	846	102	20304	1.0	0	0
14	3948	245	23688	7	987	119	23688	1.5	0.13	0.13
16	4512	280	27072	8	1128	136	27072	2.0	.13	.25
18	5076	315	30456	9	1269	153	30456	2.38	.13	.25
20	5640	350	33840	10	1410	170	33840			

the allowable for this loading. Figure 7 shows the structure under full load.

Considering the type of brick and workmanship the structure had definite weakness. A study of the sand, reported washed, indicated a large percentage of silt or loam. No organic matter was present. In addition the sand was unusually fine which probably accounts for the low strength obtained. Table VII gives the load deflection data.

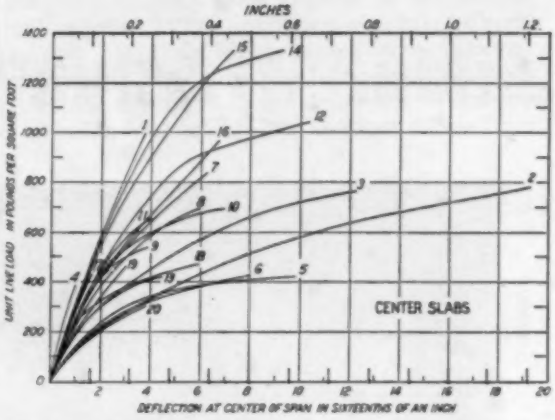


FIG. 8.—Load-deflection diagrams for 20 center slabs.

Part II. Analysis of Tests on 20 Demonstration Structures

To date twenty-five structures have been built and twenty have been tested. With the exception of two built with cement mortar they have all been built according to one design and specification. The exceptions are Tests I and VII. This work includes tests on 20 slabs and 40 beams built in widely distributed locations and with a variety of brick layers. Brick from 13 different plants were used, including 14 varieties. Tables VIII and IX give the summary of tests on slabs and beams, respectively.

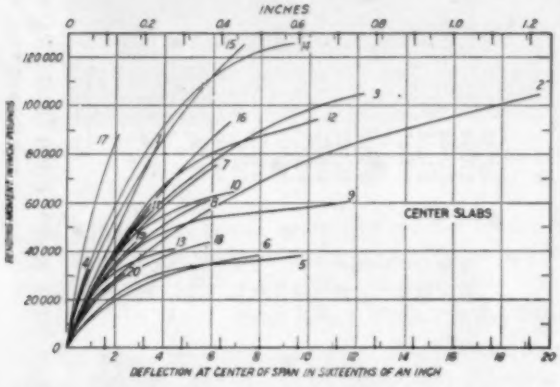


FIG. 9.—Bending moment-deflection diagrams for 20 center slabs.

(A) Slabs

The tests on 20 slabs are directly comparable for load with the exception of Tests II, XVI, and XVII where the total load on the cantilever was greater than one-quarter of the total load on the center slab, changing the conditions of moment in the slabs. Figure 8 shows the relation between live load on the center span and deflections for all of the structures. Figure 9 shows the relation between maximum bending moment in the slabs and deflections. This second set of curves reduces the variation in method of loading to a common basis. Computed values of the shearing and compressive stresses in the masonry, the stress in the

TABLE VIII

SUMMARY OF TESTS OF SLABS

Test No.	Location	Center slab			End slabs		Center slabs						
		Max. load (lb.)	Max. load (lb./sq. ft.)	Max. def. (ft.)	Max. load (lb.)	Max. load (lb./sq. ft.)	Age (days)	Max. B.M.	Max. unit shear	Max. F_s	Max. F_c	Max. bond stress	Unit load first crack	Unit load def. = 0.26 in
I	Philadelphia	14620	995	0.219	7300	995	102	85000	110	2800	40000	320	350	Failed
II	Montreal	12120	825	1.203	1364	186	38	122096	92	4030	57000	267	413	332
III	St. Louis	12300	837	0.766	1395	191	48	124000	93	4090	58300	270	608	456
IV	Allentown	6780	461	.125	1410	96	46	47500	51	1500	22300	149		Failed
V	Allentown	6598	434	.615	1739	227	37	39590	50	1250	18500	145	332	340
VI	Allentown	6924	452	.500	1739	227	36	41500	53	1310	19500	153	332	333
VII	Allentown	16440	1082		4110	536	37	98640	124	3060	46300	361	457	645
VIII	Keystone	10300	700	.375	2700	371	48	64700	78	2135	30400	226	448	612
IX	Norristown	10230	698	.734	1980	270	41	61380	77	2020	28800	251	405	540
X	Reading	11400	730	.438	2850	366	118	68400	86	2000	32100	229	423	596
XI	Washington	16206	1073	.650	4435	554	34	95500	125	2800	45000	358	560	720
XII	Washington	9677	640	.260	2688	336	34	55800	75	1640	26400	214	560	640
XIII	Baltimore	7245	442	.280	1807	219	50	47500	56	1400	22400	160	306	408
XIV	Washington	19245	1324	.50	4815	660	56	12500	153	3800	58500	427	792	968
XV	Washington	20530	1412	.46	5136	704	54	134000	163	4080	63000	455	880	880
XVI	Columbus	8900	556	.086	4450	556	184	107000	71	3250	50300	197		
XVII	Columbus	3630	220	.03	3630	220	184	87000	29	2650	41000	80		
XVIII	Baltimore	7260	468	.375	1812	234	114	43560	58	1325	20400	160	468	390
XIX	Chester	7890	495	.19	1935	240	31	47160	45	1030	15800	125	350	495
XX	Watsontown	5640	350	.19	1410	170	30	33840						350

TABLE IX

SUMMARY OF TESTS OF BEAMS

Test No.	Location	Soldier beams								Running bond beams				
		Max. load (lb.)	Max. bending moment (in.-lb.)	Max. shear (lb.)	Max. defl. (in.)	Max. F_s (lb./sq. in.)	Max. F_b (lb./sq. in.)	Max. v	Max. u	Max. defl. (in.)	Max. F_s (lb./sq. in.)	Max. F_b (lb./sq. in.)	Max. v	Max. u
I	Philadelphia	14610	306810	7305	0.095	64000	1170	65	190	0.063	68300	953	59	152
II	Montreal	7424	155904	3712	.250	32400	592	33	96	.219	34600	482	30	77
III	St. Louis	7545	158445	3773	.063	33000	605	33	98	.032	35200	492	30	78
IV	Allentown	4800	100800	2400	.063	22500	384	21	62	.203	24000	313	19	50
V	Allentown	5038	105738	2519	.003	22000	403	22	65	.156	23400	329	20	53
VI	Allentown	5201	109401	2600	.000	22800	418	23	67	.000	24400	341	21	54
VII	Allentown	12330	258930	6165	.000	54000	985	55	160	.000	57500	804	50	129
VIII	Keystone	7850	164850	3925	.086	34300	628	35	102	.071	36500	512	32	82
IX	Norristown	5940	124740	2970	.032	26000	475	26	77	.047	27800	388	24	62
X	Reading	8400	176400	4200	.063	36700	673	37	109	.032	39200	550	34	88
XI	Washington	4704	96500	2352	.15	19500	369	21	61					
		10351	217000	5176							48800	675	42	108
XII	Washington	7527	158000	3764	.163	31800	603	34	96	.093	35400	492	31	78
XIII	Baltimore	5432	114000	2716	.078	23000	435	25	70	.063	25400	335	23	57
XIV	Washington	14437	303200	7219	.175	61500	1151	66	187	.18	67500	945	58	150
XV	Washington	15400	323400	7700	.29					.28	71800	1008	62	160
XVI	Columbus	8900	186900	4450	.109	37900	710	40	115	.04	41500	583	36	92
XVII	Columbus	3630	76230	1815	.01	15450	290	16	47	.03	16900	237	15	38
XVIII	Baltimore	6442	114280	2721	.046	23200	435	25	70	.31	25400	356	22	56
XIX	Chester	5865	123190	2933	.078	25000	468	37	76	.016	27350	384	24	61
XX	Watsontown	4230	88830	2115	008	18000	338	19	55	.016	19700	277	17	44

steel, and the bond stress are given in Table VIII. They are based on an assumed value of the depth to the neutral axis of 0.38 of the depth to the steel and 0.88 of the depth for the values of the distance from center of steel to centroid of compression.

A study of Fig. 9 reveals several interesting features. The load producing the maximum allowable deflection for plastered ceilings of $^1/_{360}$ inch per foot of span is of particular interest since it is the limiting feature of design. This deflection was not obtained for any slab for a live load of less than 300 lb. per sq. ft. which is required to stress the steel to the usual design value of 20,000 lb. per sq. in. Assuming this working stress the maximum possible design bending moment is 48,500 inch-pounds. With loads producing this maximum design bending moment, thirteen slabs showed corresponding deflections less than the allowable. The remaining seven were apparently deficient in some manner; three of these are known to have had poor sand in the mortar. Those slabs that did not fail at small loads gave evidence of satisfactory performance.

Table VIII in addition to observed values gives some calculated values. The greatest load was carried by Test XV with 20,530 lb., or 1408 lb. per sq. ft. Loads ranged from this value down to 5640 lb. or 350 lb. per sq. ft. Omitting those structures with known weaknesses, the remaining ones indicate strengths far beyond design requirements. Apparently an increase in age beyond the usual twenty-eight days produces a corresponding increase in strength. Tests XI and XII at thirty-four days showed less than Tests XIV and XV using the same materials at fifty-four days.

The calculated values are of interest in a comparative respect. In no case did any of the slabs fail in compression. Figured stresses range from 1030 lb. per sq. in. to 4080 lb. per sq. in. These are values far beyond the usual accepted allowable working stresses for any kind of brick masonry. Steel stresses in many cases approach the yield point, with a maximum in Tests XV of 63,000 lb. per sq. in. The fact that most slabs developed 20,000 lb. per sq. in. or more in the steel indicates that the actual shearing, compressive, and bond stresses were not excessive. Unit shearing stresses ranged from 45 lb. per sq. in. to a maximum of 163 lb. per sq. in. in Test XV. Unit bond stresses ranged from 125 lb. per sq. in. to 455 lb. per sq. in. The unit load at first crack ranged from 350 to 880 lb. per sq. ft. No sign of failure occurred in any slab for loads under 200 lb. per sq. ft. Permitting the load to remain overnight in Tests XIV, XV, XVI, and XVII showed that in those cases there was no apparent plastic flow.

The data obtained from these tests have justified the effort required in their building. Although the work was done in the field and no attempt made to measure anything but load and deflection, the information given here furnishes a background for extensive laboratory research. The question of the effect of workmanship is seen to be secondary to materials. Slabs that apparently did not have thoroughly filled joints carried more load than those with poor sand. Given proper combination of materials, however, workmanship is an important factor.

(B) Beams

Table IX gives the values obtained in testing 40 beams. All of the beams were not tested to failure. Seven beams were actually loaded to failure, two in Test IV, two in Test XI, one in Test XIV, one in Test XV, and

one in Test XIX. The beams in Test XII showed signs of cracking but did not actually fail. The remaining beams carried varying loads ranging from 3630 to 14,610 lb.

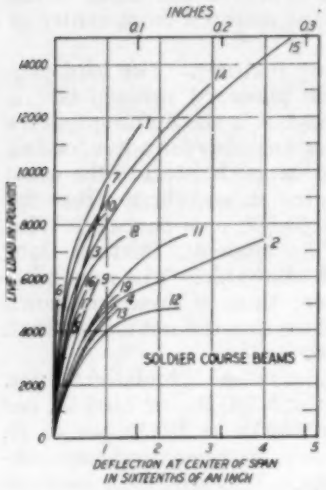


FIG. 10.—Load-deflection diagrams for 19 soldier course beams.

In considering the results of these beam tests it is important to keep in mind the original purpose The beams were designed to represent lintels usually loaded with a uniform dead wall load and in some cases a concentrated beam load. The amount of reinforcing was small. These beam tests demonstrate without a doubt that ordinary masons using recognized mortar mixes and brick from the existing market can produce a new form which is capable of performing in ways hitherto impossible for brick masonry. Even those beams that failed carried sufficient load without excessive deflection to warrant their use in ordinary lintel construction. Values of computed stresses are given only for comparison. No deformation tests were measured. The work in testing beams from Tests XVI and XVII at the Ohio State University Engineering Experiment Station, reported in Part III of this report, gives some important and interesting information.

When the slabs failed at low loads the data for the corresponding beams are only partial. The relation between load and deflection, given in Fig. 10 for soldier bond beams and in Fig. 11 for running bond beams, shows graphically just how they behaved. The chief difference between the soldier and running bond beams was that the deflection of the former was usually about 50% greater than the latter under the higher loading. This is more important in view of the fact that the steel stress was greater in the running bond beams with which greater deflections would be expected. This indicates that considerable tension exists in the masonry. Test XV at Washington carried the greatest load with the highest unit stress. Both beams in this structure were running bond and as the calculated steel stress is above 71,000 lb. per sq. in. much of the tension was apparently taken by the masonry. The compressive and shearing stresses were not excessive in any beams. Apparently when proper mortar materials were used no difficulty was experienced in developing ample bond stress.

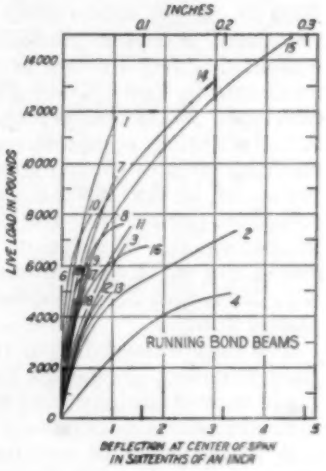


FIG. 11.—Load-deflection diagrams for 21 running bond beams.

The fact that all of these beams carried sufficient load to produce an ample factor of safety for plain lintel construction justifies such a design almost anywhere. As long as the depth is not less than 18 in. a few bars as used here can reinforce an 8-in. wall for an 8-ft. span amply for the usual needs. When concentrated or floor loads are impressed, calculations are necessary to determine their effect.

When the results of these tests are considered, several important facts stand out. First, the materials used, brick, sand, cement, lime, and water, must be of proper quality. Those meeting the standards now set for reinforced concrete apparently are adequate. The quality of the mortar affects directly the load-carrying capacity of the structure. Second, the same mortar does not act alike with all brick. Some high strength brick require richer mortars than lower strength brick. The rate of water absorption of the brick and the amount of water present at the time of laying have an important bearing on the performance of the masonry. Some recent laboratory tests, not yet reported, indicate that the initial rate, usually for the first ten minutes, is of maximum importance in obtaining the best conditions of brick for existing standard mortars. The condition of the surface of the brick also seems to affect the adhesion of brick and mortar. The presence of an excess of dust or sand on the surface of the brick tends to prevent proper adhesion of mortar. The amount of wetting of the brick for these structures is not reported, but it is known that almost all were wet to some degree. In future work the average weight of the brick as used together with their dry weight, is of considerable importance in studying results. Third, pending the development of definite standards for brick and mortar to limit design stresses, it seems that a proper mortar should be developed for each brick to produce a masonry of definite standard. With such a condition the establishment of limiting design stresses for commercial practice is a short step.

Part III. Auxiliary Tests

(A) Physical Tests of Brick Used in Demonstration Structures at Rensselaer Polytechnic Institute, Troy, N. Y.

In order to study the relation between physical properties of brick and mortar and the performance of demonstration structures a series of tests is under way at the Rensselaer Polytechnic Institute. Brick from nine plants from which demonstration structures have been built are included in the research. This work has been in progress for the past ten months by H. Duff Williamson under the direction of T. R. Lawson. Much valuable information has been developed. Early in 1932 a test program was prepared for this work and copies sent to each member of the Advisory Committee for suggestion and criticism. The following outline is the program for these tests.

Test Program

Brick, Mortar, and Bond Strength of Mortar

This test program has been prepared to determine the physical characteristics of brick used in demonstration structures now built. The object of this program is to determine the seemingly important variables of these brick and their effect on the bond and strength of mortar both in direct adhesion and in shear. The time and materials

available for this work are limited and hence only those mortars commonly recognized by building codes and one standard mortar mixed with Ottawa sand are planned. It is possible that these tests may throw some light on the ability of beams and slabs to carry varying loads as already found in testing demonstration structures built in accordance with the design and specifications set forth in Report No. 1.

(1) *Materials*

1.1 Cement

1.11 Portland (Standard A.S.T.M. C9–30)
Report brand

1.2 Lime

1.21 Hydrated (Standard A.S.T.M. C6–31)
Report brand high calcium or magnesium

1.3 Sand

1.31 Standard Ottawa
1.32 Commercial
Report sieve analysis, silt content, and result of organic content test (A.S.T.M. C40–27, C41–24)

1.4 Water

Report characteristics

1.6 Brick

Report variety (method of manufacture)
Determine and report:

(*a*) Compressive strength, flat, edge, on end (A.S.T.M. C67–31)
(*b*) Modulus of rupture, flat and on edge (A.S.T.M. C67–31)
(*c*) Absorption, 5 hr. boil, 24 hr. and 48 hr. cold immersion (A.S.T.M. C67–31, C32–24)
(*d*) Rate of absorption, 1, 5, 10, 30, 60 minutes cold immersion; report in per cent of 24 hr. cold immersion (A.S.T.M. C67–31)
(*e*) Rate of capillary absorption; immerse brick in water, constant level, observe position of water line on brick at 1, 5, 10, 30, 60 minutes; average height and calculate mean; test brick immersed as follows: end 1 in., face $^1/_8$ in., and bed $^1/_8$ in.; report height of water line above water level for time intervals specified.

II. Mortar

2.1 Mixtures (by volume)

2.11 Standard 1 part Portland cement, 3 parts standard Ottawa sand.
2.12 One part Portland cement, 0.15 part hydrated lime, 3 parts sand.
2.13 One part Portland cement, 1 part hydrated lime, 6 parts sand.
2.13*a* One part Portland cement, one part hydrated lime, 6 parts sand; add water to grout. Grout to have such consistency that one fluid ounce when poured on a glass plate from height of $^1/_8$ in. will spread in a circle 4 in. in diameter in $^1/_2$ minute.
2.13*b* One part Portland cement, 1 part hydrated lime, 6 parts sand; dry mix. Report quantity of water used per bag of cement and with exception of 2.13*a* slump test for each of these mortars.

III. Bond Strength of Mortar

3.1 Adhesion

3.12 Mortar to brick in direct tension. Use five specimens for each test. Use mortars 2.11, 2.12, 2.13. Lay two half brick, bed faces adjacent, $^1/_2$-in. joint, brick air dry, and allow to age 28 days in air. Where bed faces vary as in soft-mud brick, use one bed face of each kind in contact with mortar. Apply tension to brick by means of clamp avoiding eccentricity of applied forces. Report area in contact with mortar, total load, unit load, and character of fracture.

3.2 Shear

3.21 Mortar to brick with $^1/_2$-in. joint and following mortars: 2.11, 2.12, 2.13*a*, and 2.13*b*. Use three full brick for each specimen and five specimens for each test. Lay three dry brick with bed faces adjacent, with center brick projecting 1 in. endwise beyond other two. Allow to age 28 days in air and test in compression machine. If lateral clamp is used in testing, report pressure applied and character of devices. Report net area in contact with mortar (double shear), total load unit, shearing stress, and character of fracture.

Although the work is not complete at this time some data are available and are given as a preliminary report. Work on the physical properties of brick under 1.6 brick, (*a*), (*b*), (*c*), and (*d*), is complete for the nine varie-

TABLE X

SUMMARY OF PHYSICAL TESTS OF BRICK

Testing Laboratory, Rensselaer Polytechnic Institute, Troy, N. Y.

Test No.	Absorption by weight (%) Cold								Boil
	1 min.	5 min.	10 min.	30 min.	60 min.	5 hr.	24 hr.	48 hr.	5 hr.
I	6.70	8.79	8.84	8.84	8.94	9.21	9.96	10.42	12.64
II	2.76	4.84	6.03	6.82	6.97	7.57	8.13	8.44	10.25
IV	7.39	10.33	10.36	10.39	10.59	10.96	11.74	12.15	15.86
VIII	4.87	7.28	7.86	8.06	8.10	8.27	8.86	9.33	13.54
X	4.58	8.25	8.81	8.94	9.01	9.28	9.68	9.95	13.19
XI	5.09	6.98	7.15	7.24	7.46	7.95	8.72	9.03	11.07
XIII	0.88	1.77	2.42	3.63	4.26	5.03	5.51	5.74	7.06
XVI	0.22	0.32	0.36	0.36	0.36	0.38	0.41	0.44	1.69
XVIII	1.17	2.15	2.79	3.87	5.23	6.99	7.64	7.89	8.71

Strength				
Transverse (lb./sq. in.)		Compression (lb./sq. in.)		
Flat	Edge	Edge	Flat	End
720	860	3940	3910	2440
1030	1080	3300	2560	2720
960	1120	3310	3560	3200
890	930	6580	6440	3470
1220	1210	4860	4450	3320
990	880	4850	5460	4490
1640	1300	4340	7510	4330
3050	2860	9160	12360	4880
1440	1850	4930	6800	3080

ties included in the test. Seventeen demonstration structures have been built using these nine types of brick. The results are given in Table X.

With the complete information on the physical properties of the brick used, some information may be obtained which will explain the action of corresponding test structures under load. The results show that different brick have widely varying physical characteristics. Particular attention is drawn to the rate of absorption for the first hour.

(B) Demonstration Structures at Columbus, Ohio

Tests XVI and XVII were reported in Part I of this report, conforming with the customary arrangement. Through the accidental toppling of the load early in the test it was necessary to depart from the usual method of

testing. Accordingly the beams were removed to the Engineering Experiment Station of the Ohio State University and a complete test was conducted by J. R. Shank. Loads, deflections, and deformations were accurately measured. The following report covers this work completely and creditably.

(C) Testing of Demonstration Structures at Columbus, Ohio (Tests XVI and XVII)

By J. R. Shank

Two demonstration structures were made January 14 and 15, 1932, at the plant of the Claycraft Brick Company at Taylor's Station just east of the city of Columbus. These structures were made according to the specifications[2] and under the direction of Edward E. Krauss. A 1:1:6 cement–lime–sand by volume mortar was used. The sand was sharp and rather coarse. The cement and lime were bought on the local market. Two types of brick were used: a very hard, brown, common brick and a dark red, medium hard brick.[3] The surfaces were all rather rough and sharp. The steel used was plain, round, soft steel, having an elastic limit as indicated by the drop of the beam of 43,000 pounds per square inch. The elongation and the reduction of sections, though not measured, indicated a soft structural grade steel. The piers and beams were laid up by a bricklayer using a mortar of the usual consistency. The slabs were all grouted in. The grout was of the same material as the mortar except that more water was used. In laying the slabs rough wood boards were supported level with the tops of the beams, the brick were laid in the position they should occupy in the slab, the bars were laid on small chairs, and the grout was poured. The rods were moved backward and forward an inch or so two or three times to insure perfect bond. The grout was then smoothed off on top by means of a trowel. The harder beam brick structure was constructed January 14 and the softer brick structure January 15.

These structures are shown in Fig. 3. The structure to the left is the hard brick and that on the right or south, the soft brick structure. These structures were tested under gravity load July 14, 1932, just six months after they had been made. Deflection measurements were taken on the slabs at the ends of the cantilevers and at the mid-points between beams. Deflection measurements were also taken at the mid-points of the beams. On the afternoon of July 13, 1932, both structures were loaded with 1296 brick each making a superimposed load of 209 and 220 lb. per sq. ft. for the hard brick and the soft brick structures, respectively, or 255 and 266 lb. per sq. ft., respectively, total load. On the morning of July 15 there was no plastic flow of any appreciable amount noticeable. The hard brick structure was loaded in the morning to 32 brick high, making a total load of 601 lb. per sq. ft. At this loading the brick of the load began to weave and finally fell toward the south which broke the south cantilever largely because of the impact. Figure 4 shows the load 28 brick high and the instability of some of the piles. After this happened the north cantilever was then further loaded together with sufficient load on the interior span to counterweight the cantilever to a maximum load of 35 brick high or a total load of 655 lb. per sq. ft. The center span was then loaded with the

[2] Report No. 1.
[3] Later designated hard and soft brick.

cantilevers unloaded to 516 lb. per sq. ft. total load when the slab settled easily to the catch support. These three tests indicated that the failures were all in the steel. There were no evidences of any failures of bond. Table XI shows the deflection data for the first slab loading.

TABLE XI

DEFLECTION DATA FOR HARD BRICK STRUCTURE

	Beams		North Cantilever		South Cantilever		Center Span	
Total load (lb.)	Deflections (in.) Soldier course	Running bond	Total load (lb./sq. ft.)	Deflections (in.)	Total load (lb./sq. ft.)	Deflections (in.)	Total load (lb./sq. ft.)	Deflections (in.)
1896 D.L.	0	0	46 D.L.	0	46 D.L.	0	46 D.L.	0
1990	0		51.6	0	51.6	0	51.6	0.000
2490	0.001		80.8	0.023	80.8	0.008	80.8	0.008
3100	.003		115.5	.047	115.5	.023	115.5	.008
3705	.006		149.2	.070	149.2	.047	149.2	.016
4310	.012	0.016[b]	185	.102	185	.070	185	.016
4915	.019	.019	220	.141	220	.110	220	.016
5520[a]	.025	.0195	255	.180	255	.149	255	.016
5520[a]	.0295	.028	255		255		255	.016
6730	.0315	.033	324	.203	324	.188	324	.023
7940	.046	.043	397	.282	397	.282	397	.031
	.109		463	.368	463	.360	463	.039
			533	.477	533	.375	533	.086
			602		602		602	

NOTE: The deflections are all referred to zero deflection for the dead load (D.L.).

[a] From this reading, the loading was done the next morning. These readings were taken the night before and the next morning by means of a micrometer caliper in order to find plastic flow, if any.

[b] The readings prior to this were bad. This value, 0.016 in., was obtained by extrapolation from the general trend of the values following and the shape of the curve for the soldier course beams.

TABLE XII

DEFLECTION DATA FOR SOFT BRICK STRUCTURE

	Beams		North cantilever		South cantilever		Center span	
Total load (lb.)	Deflections (in.) Soldier course	Running bond	Total load (lb./sq. ft.)	Deflections (in.)	Total load (lb./sq. ft.)	Deflections (in.)	Total load (lb./sq. ft.)	Deflections (in.)
1808 D.L.	0	0	46	0	46	0	46	0
1892	0	0	51.1	0	51.1	0	51.1	0
2110	0	0	64.4	0	64.4	0	64.4	0.008
2413	0.001	0.001	82.7	0	82.7	0	82.7	.008
3018	.003	.003	119.4	0.023	119.4	0.023	119.4	.016
3621	.005	.008	156.2	.039	156.2	.047	156.2	.023
4223	.007	.013	192.8	.047	192.8	.070	192.8	.023
4833	.009	.019	229.7	.086	229.7	.086	229.7	.023
5438	.010	.031	266.4	.109	266.4	.117	266.4	.023
			266.4[a]	.109[a]	266.4[a]	.111[a]	266.4[a]	.025[a]
			266.4[a]	.102[a]	266.4[a]	.106[a]	266.4[a]	.030[a]

NOTE: The deflections are all referred to zero deflection for the dead load.

[a] These readings were taken the night before and the next morning by means of a micrometer caliper in order to find plastic flow, if any.

An attempt to obtain the modulus of elasticity for the slab brickwork from the deflection data and using the straight-line theory as for reinforced concrete produced 1,560,000 lb. per sq. in. Using this modulus of elasticity and the straight-line theory, a unit stress of 52,000 lb. per sq. in. in the steel was obtained for the maximum load on the north cantilever. This

maximum load caused a unit bond stress of 193 and a unit internal shear of 79 lb. per sq. in. The maximum load of 516 lb. per sq. in. on the interior span gave 50,700 lb. per sq. in. fiber stress on the steel. This confirms the observations that the failures were due to the steel.

The south or soft brick structure which had been loaded the day before to 266 lb. per sq. ft. was damaged when the fall of brick occurred on the north structure. The impact on the north cantilever of the soft brick structure due to the falling brick caused a failure on the top side of the interior span at the ends of the top bars of the north cantilever. The south or soft brick structure had been loaded to 266 lb. per sq. ft. the day before. The south cantilever was not damaged by the fall of the brick. It was loaded to 676 lb. per sq. ft. when failure occurred. No other loadings were supplied to the slab. The deflection data for the loading of the day before (July 14) are given in Table XII.

The deflections of the cantilevers of this structure are noted to be considerably less than those for the hard brick structure. This means a higher modulus of elasticity of the slab as a whole. Upon trial it was found that a modulus of elasticity could not be found to suit if the straight-line principle and the assumption that no brickwork acts in tension are used as bases. A number of moduli would suit if a variable amount of brickwork was assumed to take tension. If $E = 6{,}000{,}000$ or $n = 5$, which was found later when testing the beams of the soft brick structure, is used, the deflection conforms to theory if the depth of the brickwork acting be taken as about double that of the usual assumption. In this case it would be 1.71 inches out of a d value of 3 in. More light is thrown on this in the later beam tests. At the breaking load of the south cantilever, 676 lb. per sq. ft., the unit stress in the steel is computed, using $n = 5$, to be 42,700 lb. per sq. in. if the 1.71 in. depth is considered acting or 52,000 lb. per sq. in. if no brickwork is considered to be acting in tension. The corresponding unit stresses in the brickwork are 328 and 411 lb. per sq. in., respectively. The unit shear and bond as ordinarily figured are 97 and 258 lb. per sq. in., respectively.

The beams showed no evidences of failure after the gravity loadings. In order to obtain more reliable information from them, they were transported ten or twelve miles to the laboratories of the Ohio State University Engineering Experiment Station for further test. These beams were mistakenly inverted in the loading, and were transported upside down. Two of the beams were evidently damaged in transportation and another may have been cracked. Because of fear of further damage, these beams were handled at the laboratory and tested in the inverted position. Deflection measurements and strain measurements near the outer fibers in compression and on the outer fibers of the steel at the center were taken in all cases. In the case of the one beam (soft brick structure running bond) showing the least evidences of damage additional measurements were taken at the point of maximum bending on all mortar joints from top to bottom on both sides. These extra measurements were made to check up on the fiber deformation behavior or in other words, to find out if a straight line before bending remained a straight line after bending as is known to be the case for homogeneous elastic materials such as steel. These beams in the discussion are known as (1) hard running bond beam, (2) hard soldier course beam, (3) soft running bond beam, and (4) soft soldier course beam.

No. 1 Hard Running Bond Beam

This beam was damaged in transit. One of the brick near the center on the compression side had dropped out, which indicated that cracks on

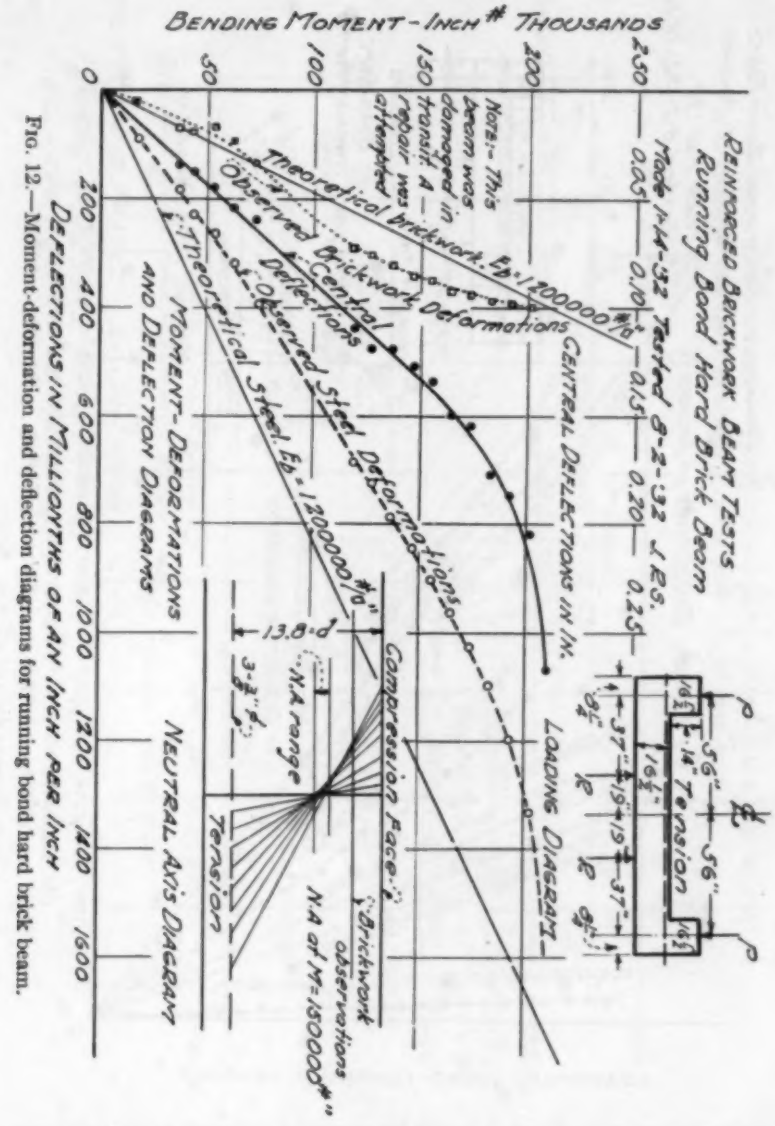


Fig. 12.—Moment-deformation and deflection diagrams for running bond hard brick beam.

the compression side had opened. Several days before testing the beam, this brick was reset with a rich cement mortar. Figure 12 shows diagrammatically how the beam was loaded as well as all of the important test

results. This beam failed at a total load just short of 12,000 lb. The failure was evidenced by a number of the joints near the middle opening-up at one of which the steel began to elongate, being stressed beyond the

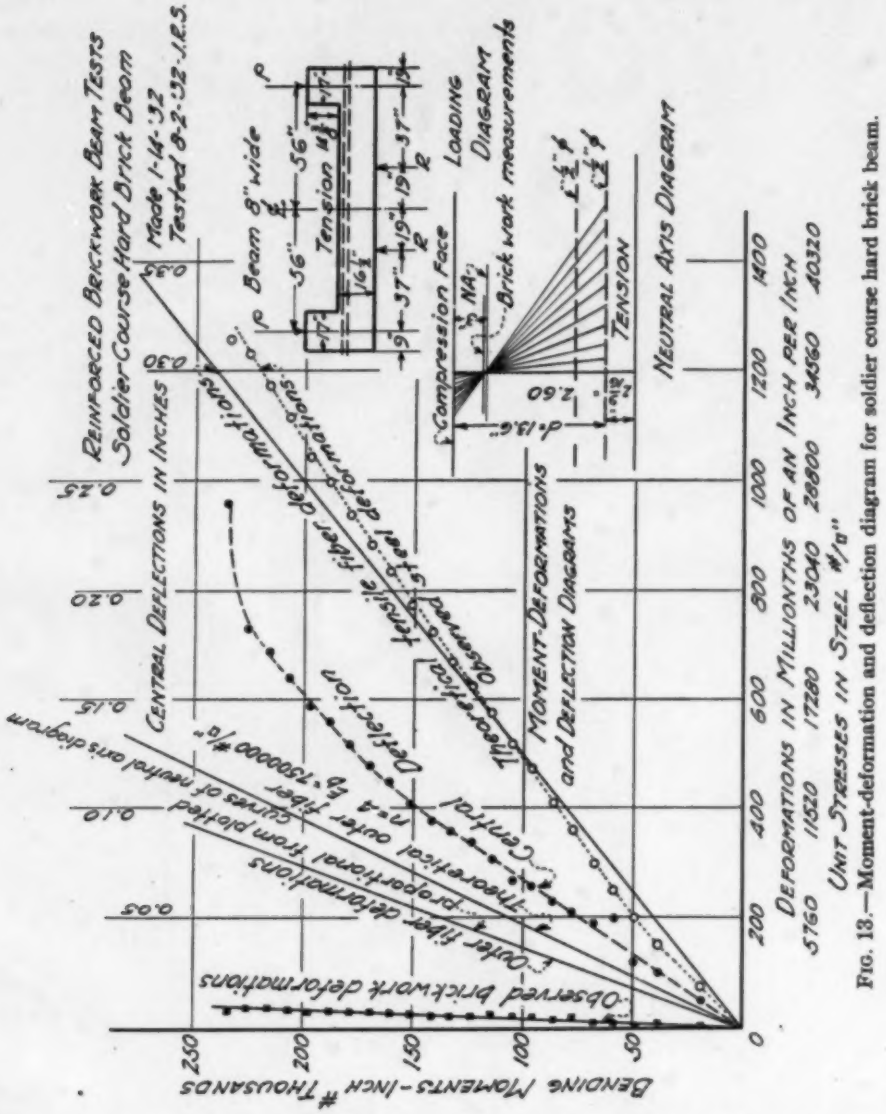


FIG. 13.—Moment-deformation and deflection diagram for soldier course hard brick beam.

elastic limit. Loading was stopped when it was found that further running of the testing machine could not raise the beams at 12,000 lb. There was no evidence of crushing of the brickwork or of any slipping of the bars. This laboratory test made it possible to obtain more accurately the modulus

of elasticity. The neutral axis diagram defined the location of the neutral axis and this, together with the deflection data, made it possible to determine the modulus of elasticity and how much of the brickwork was acting

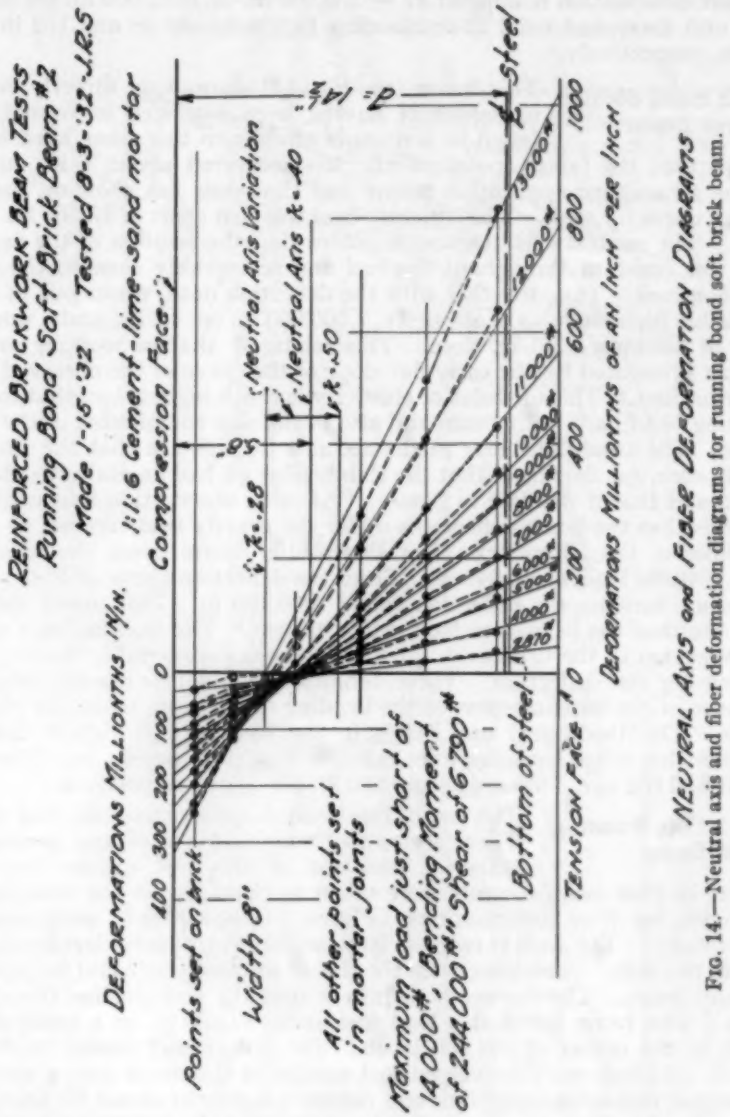


FIG. 14.—Neutral axis and fiber deformation diagrams for running bond soft brick beam.

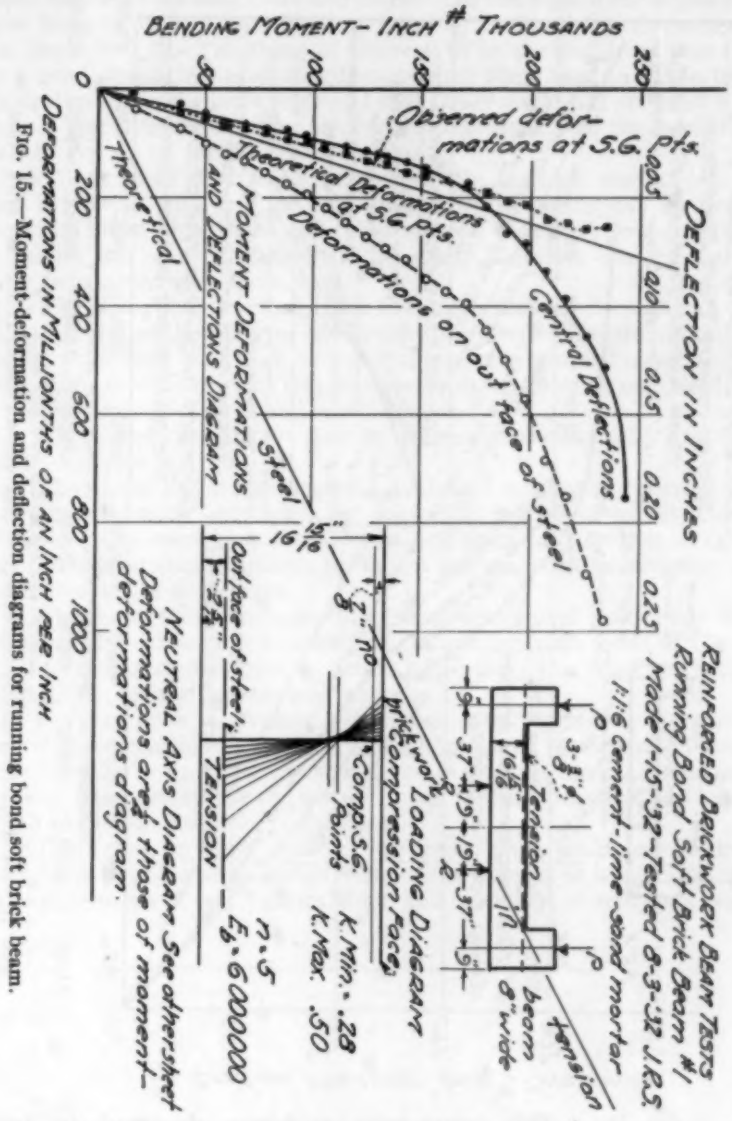
in tension. At a bending moment of 150,000 in.-lb. the modulus of elasticity worked out to be 1,200,000 lb. per sq. in.; also 10 in. depth out of the 13.8 in. to the steel was found to be acting. The observed brickwork deformation showed the effect of the damage. At M = 150,000 in.-lb. the

cracks in the compression side had apparently been closed. The theoretical curves are figured on the basis E = 1,200,000 lb. per sq. in. and that no brickwork acts in tension. The theoretical unit stress in steel at the last deformation reading at M = 200,600 in.-lb. is 49,000 lb. per sq. in. The unit shear and bond at the loading 11,500 lb. are 58 and 132 lb. per sq. in., respectively.

No. 2 Hard Soldier Course Beam This beam (see Fig. 13) showed no directly visible evidences of having been damaged in transit. It failed in a manner similar to the other hard beam except that the failure point in the steel occurred about 4 in. outside of the strain-gage application points and thus does not show on the observed curve for steel. The ultimate load was just short of 13,500 lb. total load. The neutral axis diagram indicates that the position of the neutral axis was constant throughout the test and remarkably close to the compression face. This, together with the deflection data, works out to a remarkably high modulus of elasticity, 7,500,000 lb. per sq. in., and a working area of brickwork 5.5 in. deep. This relatively shallow working area is further illustrated by the early flat slope of the curve of the observed steel deformations. This modulus of elasticity is much higher than that for the running bond hard brick beam and also of the slab constructed of the hard brick. The conditions that might account for this are that the running bond beam was damaged, that the slab brickwork had an entirely different bond, and that it was laid in grout. One other observation that might be made is that the beam deflections under the gravity loads are not as large as those of the laboratory. For this soldier course beam the deflection at a 7940 lb. load was 0.046 in. From the deflection curve of Fig. 13, for the same bending the deflection would be 0.109 in. This would seem to indicate that the beam was loosened in transit. The working area of the cross-section of the brickwork might have been considerably deeper, thus decreasing the deflection. These conditions can not be closely compared because of the indefiniteness of the bending of the beam under the gravity loads. The theoretical unit stress in the steel at the highest bending moment for which readings were taken is 33,600 lb. per sq. in. The unit shear and the unit bond are 68 and 200 lb. per sq. in., respectively.

No. 3 Soft Running Bond Beam The test of this beam is the most satisfactory of all. There seems to be no evidence of any damage in transit. The test of this one differs from the others in that measurements were taken to check up on the straight-line principle for fiber deformations. Figure 14 shows these measurements graphically. The scale is twice as large as the neutral axis diagrams shown for all the tests. This checks up the theory as closely as could be expected on any beam. The answer is definitely that the straight-line theory applies. This beam failed at a load just under 14,000 lb. or a bending moment at the center of 244,000 in.-lb. The failure was similar to that of No. 2. A large crack developed just outside of the strain-gage points and zigzagged down through brick and mortar roughly at about 15 degrees to the vertical. The neutral axis diagram as well as the moment-deformation and deflection diagrams (Fig. 15) show that the beam in the test started with much of the whole cross-section working. Cracks then mounted higher and higher until after 150,000 in.-lb. the steel took practically all the tension. At 150,000 in.-lb. bending moment the modulus of elasticity

worked out to be 6,000,000 lb. per sq. in. and the area working was 10.65 in. deep. The large variation of the observed deformation curve from that of the theoretical curve may be laid to the great assistance the brick-



DEFORMATIONS IN MILLIONTHS OF AN INCH PER INCH

Fig. 15.—Moment-deformation and deflection diagrams for running bond soft brick beam.

work offered to the steel in helping to resist the tension. The theoretical curve at 235,000 in.-lb. bending moment shows a unit stress of 52,600 lb. per sq. in. The unit shear and unit bond at this loading are 60 and 135 lb. per sq. in., respectively. The beam deflection 0.031 in. at 5438 lb.

gravity load compares favorably with 0.029 in. for the same bending at the laboratory. This confirms the observation that the beam was undamaged in transit.

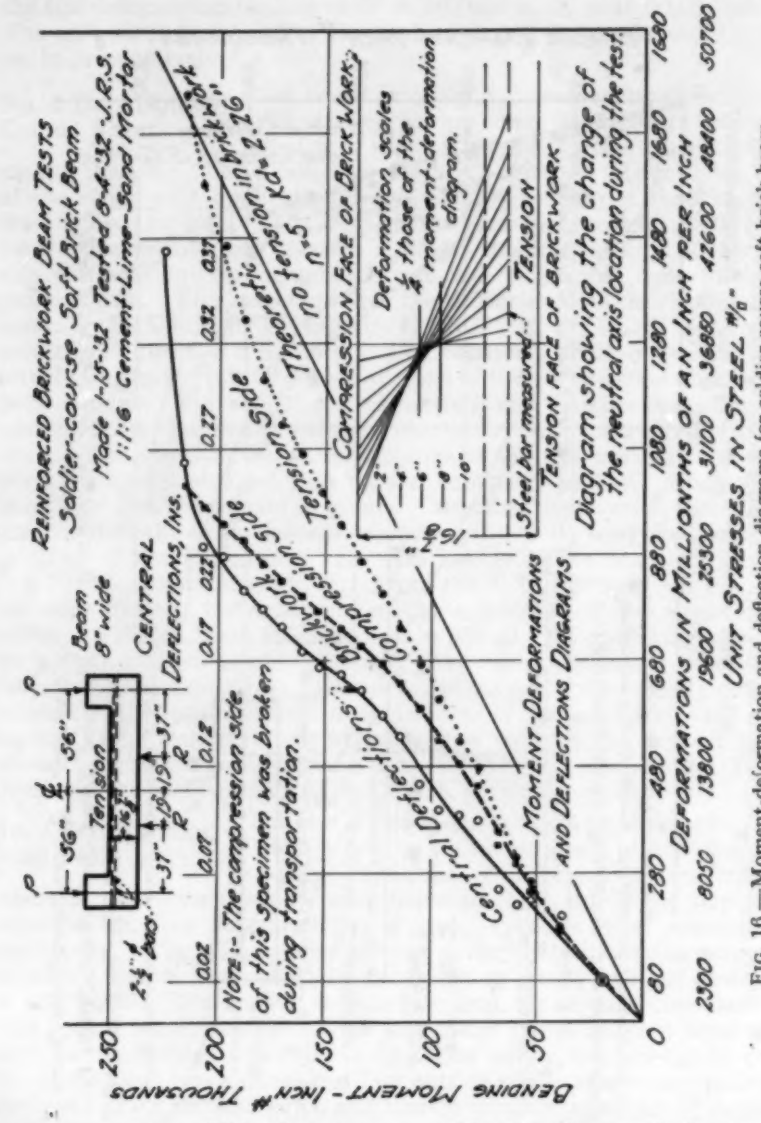

Reinforced Brickwork Beam Tests
Soldier-course Soft Brick Beam
Made 1-15-32 Tested 6-4-32 U.R.S.
1:1:6 Cement-Lime-Sand Mortar
Beam 8" wide
Central Deflections, Ins.
Tension Side
Theoretic Tension in Brickwork
n=15 kd=2.76
Compression Face of Brick Work
Deformation scales ½ those of the moment-deformation diagram.
Steel bar measured
Tension
Tension Face of Brickwork
Diagram showing the change of the neutral axis location during the test.
Moment-Deformations and Deflections Diagrams
Deformations in Millionths of an Inch per Inch
Unit Stresses in Steel #/□"
Bending Moment - Inch# Thousands
Note:- The compression side of this specimen was broken during transportation.

Fig. 16.—Moment-deformation and deflection diagrams for soldier course soft brick beam.

No. 4 Soft Soldier Course Beam This beam was evidently damaged in transit. Cracks across the compression face and into the beam were evident. This beam failed at 13,000 lb. load. The effect of these cracks is shown in the neutral axis diagram as well as in the moment-deformation and deflection diagrams (Fig. 16).

At 120,000 in.-lb. the observed deformation and deflection appeared to stiffen. This was apparently at the time when the cracks on the compression side had closed up and at the same time that the cracks in the tension side were opening more and more. The theoretical curve was drawn on the basis of $E = 6{,}000{,}000$ lb. per sq. in. as found for the other soft brick beam No. 3. The thing of interest to be derived from this test is that a good strength was obtained even when there was no aid in tension to be derived from the brickwork and that these cracks did not start a bond failure. The theoretical curve for tensile deformation on the steel showed 49,500 lb. per sq. in. for the 13,000-lb. load.

These tests serve only as a glimpse into the internal workings of reinforced brickwork and nothing but indications of truths can be derived. It must be noted that shear and bond stresses were very low and that in all cases for the beams the steel was decidedly the weak side. Some indications to be noted are as follows:

(1) The straight-line principle for fiber deformations does apply.

(2) For proper bonding of the brickwork the tensile aid to the steel from the brickwork is as high or higher than for reinforced concrete.

(3) High moduli of elasticity can be obtained from strong hard brick and properly made, placed, and cured mortar.

(4) There is little plastic flow in reinforced brickwork; much less than for concrete.

(5) The stress known as diagonal tension in reinforced concrete is not present in reinforced brickwork for brick and mortar of quality such as used here. The corresponding stresses are shear and tension along and across the mortar joint, but this tension is not greater than the unit shear times the cosine of 45 degrees.

(6) The important fundamental tests to determine values for design for reinforced brickwork are shear along a mortar joint, bond of the steel in the mortar joint, and tension across a mortar joint, together with the usual strength tests of mortar and brick.

(7) Further tests on beams should be made on beams more nearly balanced in reinforcement and of such shapes and conditions of loading as to bring out the unit internal shears and bonds so as to make the proper transition from independent test of bond shear, tension, and mortar strength to the same stresses in the beam.

(8) There are no good reasons apparent why reinforced brickwork can not be designed and constructed in such a manner as to meet all structural requirements of safety, durability, and economy, as well as of beauty.

ACTIVITIES OF THE SOCIETY

AMERICAN CERAMIC SOCIETY SUMMER MEETING AT CENTURY OF PROGRESS

Program for June 25 to July 1, 1933

Registration: Stevens Hotel (no registration fee).
Participation in general program of Engineers' Week and various participating organizations.

Monday, June 26

Informal get-together dinner at Stevens Hotel at 7:00 P.M., $2.00.
Speakers: John C. Hostetter, President of the American Ceramic Society and Corning Glass Works, Century of Progress official, and other important guests.

Tuesday, June 27

Ceramic Day at a Century of Progress.
This is also "Porcelain Enamel Day." All who wish may meet with enamelers at the Porcelain Enamel Parade, 3 P.M.
No other meetings scheduled in order to allow members full participation in programs of other societies.
A special block of rooms at Hotel Stevens has been reserved for ceramists. Please make reservations direct with John F. Bowman, Director, Conventions and Exhibits, Stevens Hotel.

Room with double bed and bath for one person, per day:
$3.00, 3.50, 4.00, 5.00, 6.00, 7.00, and 8.00.
Room with double bed and bath for two persons per day:
$4.50, 5.00, 6.00, 7.00, 8.00, 9.00, and 10.00.
Room with twin beds and bath for two persons, per day:
$6.00, 7.00, 8.00, 9.00, 10.00, and 15.00.
Parlors connected with bedrooms, per day:
$5.00, 8.00, 9.00, 10.00, and 15.00.

LOCAL SECTION NEWS

Chicago Section

April 25, 1933
Frank Hodek, Jr., Presiding

Chairman of the Membership Committee, John Owen, reported sale of ten memberships in 1932.
Treasurer reported net balance of $322.09. Moved and seconded report be accepted.
Report of Summer Meeting Committee and suggested program approved.
Committee was authorized to draw on Chicago Section treasury, not to exceed $50, for incidental expenses in connection with Summer Meeting of the Society.
Officers elected for ensuing year were as follows:

Chairman, Frank Hodek, Jr.
Vice-Chairman, G. G. Hanson
Secretary-Treasurer, H. V. Kaeppel

The following members of the advisory committee to the Department of Ceramics, University of Illinois, were reëlected:

Chairman, Douglas F. Stevens
Harry J. Lucas
William Schlake
C. J. Uhrmann
Frank Hodek, Jr.
E. H. Haeger

Moved, seconded, and passed that C. W. Parmelee be requested to serve again as councillor for the Section.

The business meeting was followed by a joint meeting with the Chicago District Enamelers Club. W. H. Zachariasen gave an interesting talk on "Atomic Arrangement in Glass."

Baltimore-Washington Section

The members of the Baltimore-Washington Section of the American Ceramic Society held their last meeting of the 1932–1933 season on April 8, 1933. Twenty-one members were present. W. Stencker, Chief Chemist of the Philadelphia Quartz Company, presented a paper on "Some Uses of Sodium Silicate in the Ceramic Industry."

The following officers were elected for the 1933–1934 period:

Chairman, Richard Türk, Porcelain Enamel & Mfg. Co., Baltimore, Md.
Vice-Chairman, L. E. Mong, Bureau of Standards, Washington, D. C.
Secretary-Treasurer, C. Hahner, Bureau of Standards, Washington, D. C.
Councillor, W. A. Weldon, Locke Insulator Co., Baltimore, Md.

BY-LAWS OF THE MATERIALS AND EQUIPMENT DIVISION OF THE AMERICAN CERAMIC SOCIETY

Article I

Object

The object of this Division shall be to assemble, discuss, and promulgate technical and engineering data relating to raw materials and equipment used in the ceramic industries, and uses and processes pertaining to these, and to promote the objects of the American Ceramic Society in general.

Article II

Membership

Members of this Division must be members of the American Ceramic Society and shall be of two grades. Voting members shall consist of those who have declared that their major interests lie within the field covered by this Division, and will have the same status in the Division and in the Society as determined by the Constitution of the Society. Nonvoting members shall consist of those who have declared that their second interest lies within the field covered by this Division. Nonvoting members will have exactly the same status in the Division as voting members except in matters pertaining to nominations and elections of representatives of this group for the general society.

Article III

Dues

There shall be no dues in addition to the dues for membership in the American Ceramic Society.

Article IV

Section 1

The officers shall be a Chairman, Vice-Chairman, Secretary-Treasurer, and Councillor, elected to serve one year, or until their successors have qualified. They shall take office at the last session of the Annual Meeting at which they are elected.

Section 2

The Affairs of this Division shall be directed by an Executive Committee comprised of the elected Chairman, Vice-Chairman, Secretary-Treasurer, Councillor, and Trustee. The Chairman, Vice-Chairman, Secretary-Treasurer, and Councillor shall serve on the Executive Committee for a period of two years after termination of their respective offices.

Section 3

Chairman: The Chairman shall have supervison of the affairs of the Division and perform such other duties as usually pertain to this office.

Section 4

Vice-Chairman: The Vice-Chairman shall perform the duties of the Chairman in his absence or incapacity.

Section 5

Secretary-Treasurer: The Secretary-Treasurer shall keep proper minutes of all meetings of the Division, shall conduct and keep a full record of the correspondence of the Division, and shall perform such duties as may from time to time be assigned to his office by the Chairman of the Division. A vacancy in the office of Secretary shall be filled by appointment by the Chairman and Vice-Chairman.

Section 6

Councillor: The Councillor's duties shall be defined by the Chairman.

Article V

Nominations and Elections

Section 1

The retiring Chairman at each Annual Meeting shall appoint a nominating committee of three members, and also two voting members who shall represent the Division on the Nominating Committee of the American Ceramic Society.

Section 2

The Division nominating committee shall submit to the Chairman by October 1, from the list of active members of the Division, the names of the nominees for Chairman, Vice-Chairman, Secretary-Treasurer, Councillor, and, when required, Trustee of the American Ceramic Society, accompanied by their acceptance of such nomination in writing.

Section 3

Additional nominations may be made s follows:

(*a*) By petition of ten members in writing, provided the petition is accompanied by the nominee's acceptance in writing and is received by the Secretary of the Division prior to December 15. In this case the names will be entered upon the printed ballot in alphabetical order.

(*b*) By the voters writing in the names of members of the Division upon the blank spaces provided on the printed ballot, as in paragraph (6), section (5), of this article, at the time of voting. In this case the nominee's acceptance must be received by the Secretary of the Division prior to the close of the ballot.

Section 4

The report of the nominating committee of the Division shall be communicated to the membership through the November *Bulletin of the American Ceramic Society.*

Section 5

The election shall be by letter ballot conducted as follows:

(*a*) The Chairman of the Division upon receipt of the nominating committee's reports as provided in Sections (2) and (4) of this Article, shall certify to the General Secretary of the American Ceramic Society the names so submitted. The General Secretary shall then cause the names to be published as provided in Section (4) of this Article.

(*b*) Not later than thirty days before the Annual Meeting, the General Secretary shall mail to each voting member of the Division not in arrears, printed ballots containing alternately the names so submitted and blank spaces for use as in Section (3) of this Article.

(*c*) Said ballots shall be enclosed in an envelope on which there shall be no mark of identification other than the word "ballot." The ballot envelope shall

be enclosed in another envelope for mailing, addressed to the Secretary of the Division, upon the back of which the voter shall endorse his name.

(*d*) The balloting shall close at twelve o'clock noon on the fifth day preceding the opening session of the Annual Meeting, and the actual date shall be printed on the ballot.

(*e*) The envelopes and ballots shall be opened in the presence of three scrutineers, appointed by the Chairman, who will report the results of the election at the first session of the Division of the Annual Meeting.

(*f*) A plurality of affirmative votes cast shall elect.

Article VI

Standing Committees

Except as otherwise provided, the following standing Committees (with duties as prescribed in the Constitution of the American Ceramic Society) shall be appointed annually by the Chairman of the Division. Other committees not conflicting with the Constitution of the American Ceramic Society may also be appointed by this Chairman.

Rules	Standards
Membership	Programs
Research	Data

Article VII

Meetings

Section 1

The annual meeting shall be at the time and place of the Annual Meeting of the American Ceramic Society.

Section 2

Special meetings of the Division may be called by the Chairman, or by petition of ten active members, upon thirty days notice.

Section 3

Five per cent of the total voting membership present, but not less than fifteen voting members, shall constitute a quorum and the majority shall rule.

Section 4

Order of Business. The order of business at the Annual Meeting shall be as follows:

(1) Reading of minutes of previous meetings
(2) Secretary's report
(3) Committee reports
(4) Unfinished business
(5) New business
(6) Announcement of the election of officers
(7) Reading of papers
(8) Installation of officers and appointment of committees
(9) Adjournment

Article VIII

Amendments

Amendments to these By-Laws must be proposed by ten members at a regularly constituted meeting of the Division, and when approved by the Committee on Rules of the Division shall become legal when endorsed by a two-thirds vote of the members present at any Annual Meeting.

BALLOT RESULTS ON RECOMMENDED CONSTITUTIONAL CHANGES

L. E. Barringer, Chairman of the Rules Committee of the Society has forwarded to the Secretary's office the ballot results on the recommended changes in the Constitution of the American Ceramic Society.[1] In the résumé Mr. Barringer states that 144

[1] These proposed Constitution and By-Law Amendments were published in *Bull. Amer. Ceram. Soc.*, **12** [4], 100–104 (1933).

votes were cast, two of the ballots were signed but no vote was indicated, a single ballot disapproved all changes, 121 votes approved all changes, and the rest were split.

The results are overwhelmingly in favor of the proposed changes and they may now be declared approved and effective as of this date (May 3, 1933).

Article	Section	For	Against
II	(3) Honorary Members	137	3
II	(5) Fellow Members	131	2
II	(6) Nomination of Fellows	132	4
II	(14) Reference Change	133	1
VII	(2) Reference of Policies	131	6
VII	(3) Delete	127	1
VII	(4) Charges against Members	130	6
VII	(5) Delete	128	1
VII	(6) Delete	128	1
VII	(7) Fellow Officers	131	2
VII	(8) Meetings of Fellows	132	1
VII	(9) Section Reference Change	130	1
VII	(10) Fellow Dues	132	3
VIII	Division Editorial Committees	138	2
XI	Publications	136	2
IV	Executive Committee	131	3
VI	Management Committee	128	3

NECROLOGY

Charles S. Maddock

Charles S. Maddock, retired pottery manufacturer, died at his home in Trenton, N. J., on April 25, 1933. Mr. Maddock, who was eighty-one years old at the time of his death, was born in upper New York State and in 1881 moved to Trenton with his father, Thomas Maddock, who is said to have been the first man in the United States to manufacture sanitary earthenware successfully. The firm of Thomas Maddock Sons Company was organized and Charles S. Maddock was active as treasurer of this company. He was also actively allied with the Maddock Pottery Company and the Johnathan Bartley Crucible Company until 1925, when he retired from business. The Maddock business later was absorbed by the Standard Sanitary Manufacturing Company. Mr. Maddock is survived by a daughter and two sons, Charles S. Maddock, Jr., and Archibald M. Maddock, the latter president of Thomas Maddock Sons Pottery.

Mark A. Haley

Mark A. Haley, ceramist at the Onondaga Pottery Company for forty-three years and a lifelong resident of Syracuse, N. Y., died in April, 1933. Mr. Haley was graduated from the College of Fine Arts, Syracuse University, in 1890 and from that time was associated with the Onondaga Pottery Company as designer and production engineer. He also took a special course in ceramics at Alfred University. As an authority on design and decoration on pottery he frequently was called upon to lecture on the subject.

OFFICERS AND COMMITTEE APPOINTMENTS FOR THE AMERICAN CERAMIC SOCIETY FOR 1933–1934

Officers of the Society

President, John Clyde Hostetter
Vice-President, Louis J. Trostel
Treasurer, H. B. Henderson
Secretary and Editor, Ross C. Purdy
Past-President, Eckardt V. Eskesen

OFFICIAL PERSONNEL FOR 1933–1934

	Art	Enamel	Glass	Materials and Equipment	Refractories	Structural Clay Products	Terra Cotta	White Wares
Trustee	C. L. Sebring	W. C. Lindemann	Francis C. Flint	V. V. Kelsey	J. M. McKinley	R. B. Keplinger	R. L. Clare	D. P. Forst
Chairman	L. E. Barringer	A. I. Andrews	H. H. Blau	Geo. H. Brown	R. A. Heindl	J. O. Everhart	R. F. Grady, Jr.	Louis Navias
Vice Chairman			James Bailey	R. B. Carothers	H. E. White		R. L. Clare	
Secretary	E. de F. Curtis	W. N. Harrison	S. R. Scholes	C. H. Peddrick, Jr.	R. B. Sosman	W. C. Rueckel	H. E. Davis	R. F. Geller
Research	Paul E. Cox	R. R. Danielson	G. W. Morey	F. P. Knight, Jr.	D. W. Ross	R. K. Hursh A. F. Greaves-Walker	Hewitt Wilson	F. P. Hall
Standards (*a*) *Tests* (*b*) *Products*	E. de F. Curtis L. E. Barringer	C. J. Kinzie	(*a*) W. C. Taylor (*b*) J. Bailey	W. J. Watkins B. C. Burgess	(*a*) S. M. Swain (*b*) E. H. Van Schoick	(*a*) D. A. Moulton (*b*) R. E. Arnold	(*a*) A. Lee Bennett (*b*) P. W. Lee	R. F. Geller
Membership	Charles Harder	W. H. Pfeiffer	W. F. Curtis	C. H. Peddrick, Jr.		Harold Dingledine	Thad. O. Smith	Geo. Simcoe
Data		H. D. Carter	A. N. Finn	R. B. Ladoo	G. J. Bair	Amos Potts	H. D. Callahan	F. P. Knight, Jr.
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Standards, Arthur S. Watts
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American Foundrymen's Association (Refractories Comm.), L. C. Hewitt
International Union of Chemistry, Alexander Silverman
Safety Association, Joseph N. Holmes

NOTES AND NEWS

CERAMIC SCHOOL NOTES

North Carolina Student Branch

At a recent election of officers for the next academic year the North Carolina Student Branch of the American Ceramic Society elected the following officers:

President, W. R. McLain
Vice-President, C. H. Armfield
Secretary, J. B. Sauls
Treasurer, H. M. Hamburger
Member-at-Large on Engineers Council, R. B. Worth

W. R. McLain, the new president, is one of the outstanding scholarship students of the college.

WEST VIRGINIA UNIVERSITY
DEPARTMENT OF CHEMICAL ENGINEERING
COURSE IN PRACTICAL POTTERY

During the first term of the summer session there will be offered a course in practical pottery in the Chemical Engineering Laboratories, Mechanical Hall, June 12 to July 21, 1933.

The work will consist of preparing the body mixes from the raw materials, shaping and firing the ware, glazing and again firing the glazed ware, and decoration. Instruction will be given in shaping the ware by hand molding, jiggering, pressing, and casting.

The practical instruction will be given by Thomas Parker, instructor in pottery, Wheeling High School. Mr. Parker served his apprenticeship in the pottery industry in England. Since coming to this country he has had practical experience in several potteries producing tableware and artware. Some of his work was exhibited at the San Francisco Exposition in 1915. Mr. Parker has had teaching experience at the Peoples' University, St. Louis, and at the Wheeling High School.

Those desiring to take the course for credit should register for Ch.E. 101s, 2 hours credit, which will require work in the clay shop three consecutive hours a day, five days a week. If the teaching time permits in the clay shop, students may be admitted to take work without credit, putting in such regular time as their schedule may permit. Those showing special proficiency or those able to put in extra time, if necessary, may be able to complete, in addition to the regular work, a small breakfast set or a tea set for their own use.

No fee is charged for the course, but students taking the course must be registered for the first term of the summer session. Registration day is June 12.

Facilities in the clay shop will take care of a limited number of students only. Those desiring particularly to take the course are requested to write to W. A. Koehler, College of Engineering, West Virginia University, Morgantown, W. Va.

ROBINEAU MEMORIAL AWARD TO ARTHUR E. BAGGS

Arthur E. Baggs, head of the Ceramic Art Department, Ohio State University, has been announced as winner of the Robineau Memorial Award for Ceramics at Syracuse, N. Y.

Professor Baggs received a cash prize of $50 for his exhibit of four pieces of pottery. The Robineau Award was founded by the late Mrs. Adelaide Alsop Robineau of Syracuse, outstanding ceramist, and carries with it high honors in the ceramic field.

The jury of award is composed of Carleton Atherton, Department of Fine Arts, Ohio State University, and a former associate of Mrs. Robineau, and prominent artists from Syracuse.

MEETINGS OF THE OHIO CERAMIC INDUSTRIES ASSOCIATION

Division Meetings in May, 1933

Joint meetings of the Structural Clay Products and the Refractories Divisions of the Ohio Ceramic Industries Association were held at the Roseville Experimental Plant on Friday, May 12, 1933. The program presented at these sessions was as follows:

Joint Sessions:

(1) "Care of Clay Mines during No-Work Period," by H. E. Nold, Mines Department, Ohio State University.

(2) "Electro-Lubrication of Dies and Molds," by J. O. Everhart, Clay Products Experimental Plant, Roseville, Ohio.

(3) "Reducing Power Costs in Clay Plants," by H. W. Bibber, Dept. of Electrical Engineering, Ohio State University.

Refractories Division:

(4) "An Investigation of Insulating Refractories, Their Manufacture, Properties, and Commercial Application," by G. A. Bole, Research Professor, Ohio State University.

Structural Clay Products Division:

(5) "Demonstration of Power Demand and Power Factor Measurement," by H. W. Bibber.

White Wares Division

On May 26 the White Wares Division of this Association met in East Palestine,

Ohio. During the morning, plant visits were made to the W. S. George Pottery Company and to the Electrical Refractories Company.

Luncheon was served at the East Palestine Country Club and the members enjoyed a golf match during the afternoon. At 5:45 P.M. a dinner was served followed by the technical paper session.

(1) Report of the Research Committee, including a report of the Committee and a proposed research program, E. H. Lintz, Chairman.

(2) "A Study of the Standardizing of Turpentines for use in the Application of Decal," by G. A. Loomis, Research Engineer.

(3) "Progress Report on Cleaning Fire Clay for Use in Whiteware Bodies," by M. C. Shaw, Research Engineer.

(4) "Study of the Physical Properties of Fluxed Whiteware Bodies," by G. A. Loomis.

(5) "The Use of Insulating Refractories in Kiln Construction," by G. A. Bole.

W. H. Locke Anderson of the W. S. George Pottery Company was in charge of the local arrangements for this meeting.

TWELFTH ANNUAL MEETING OF THE PERMANENT COMMITTEE ON SIMPLIFICATION OF VARIETIES AND SIZES OF VITRIFIED PAVING BRICK[1]

The Twelfth Annual Revision Conference of the Permanent Committee met at 10:30 A.M., April 12, 1933, at the Department of Commerce, Washington, D. C.

The following members of the committee were present:

R. Keith Compton, American Society of Civil Engineers, c/o Department of Public Works, Richmond, Va.

P. H. Bates, Division of Clay and Silicate Products, Bureau of Standards, Washington, D. C.

T. R. Lawson, American Society for Testing Materials, Rensselaer Polytechnic Institute, Troy, N. Y.

E. W. McCullough, Dept. of Manufacture, United States Chamber of Commerce, Washington, D. C.

O. W. Renkert, American Ceramic Society, c/o Metropolitan Paving Brick Co., Canton, Ohio.

G. F. Schlesinger, Chief Engineer, National Paving Brick Association, Press Building, Washington, D. C.

P. St. J. Wilson, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

C. N. Connor (representing Pere F. Seward, Engineer), American Road Builders' Association, Washington, D. C.

R. W. Crum, Director, Highway Research Board, National Research Council, Washington, D. C.

A. B. Galt, Division of Simplified Practice, Bureau of Standards, Washington, D. C.

Others attending the meeting were W. C. Perkins, Chief Engineer, Eastern Region, National Paving Brick Association, Washington, D. C.

F. L. Manning, Peebles Paving Brick Co., Portsmouth, Ohio.

Q. A. Campbell, Asst. Chief Engineer, National Paving Brick Association, Washington, D. C.

George A. Cooper, Division of Simplified Practice, Bureau of Standards, Washington, D. C.

Professor Lawson acted as Chairman *pro tem*, in the absence of the Chairman, George F. Fisk.

The minutes of the Eleventh Annual Meeting were read and approved.

Mr. Schlesinger then presented the 1932 survey, prepared by the National Paving Brick Association, and for the benefit of the other members analyzed the tables, text, and charts. The Committee's particular attention was devoted to the explanatory text which accompanied illustrations "D-33" and "E-33." Those parts of the survey which are explanatory of the illustrations are attached.

In commenting on the 1932 survey, Messrs. Renkert and Manning, as representatives of the brick manufacturers, discussed probable future trends in sizes and types. They

[1] Held at the Department of Commerce, Washington, D. C., April 12, 1933.

concurred in the opinion that the vertical fiber lug brick is rapidly growing in popularity, and its use can reasonably be expected to become greater.

R. Keith Compton, Vice-Chairman, having been unavoidably delayed, arrived at the conclusion of this discussion and assumed the chair.

At the request of Prof. Lawson, Mr. Renkert discussed for the information of the members recent developments in connection with the de-aerating process used in the manufacture of paving brick. Professor Lawson had some further information on the effect of this process as applied to building brick. It was stated that the resulting product was about 4% heavier, due to a greater density, but that it furnished a much higher compressive strength than the product of the more usual process.

The chairman requested the secretary of the Committee, Mr. Galt, to state the general formula which the Committee applies in deciding on additions to or eliminations from the recognized list of sizes. This general policy is as follows:

> "That any type of brick which shows less than 2½% of shipments for three successive years be eliminated from the list of recognized varieties, and any type of brick which shows 5% or more of shipments for three successive years be reinstated, unless special technical or other reasons prove that such action is undesirable; and provided further, that the recognized varieties shall not represent less than 75% of total shipments."

A study of the percentages for all types of paving brick during the years 1930, 1931, and 1932 developed the fact that under the above procedure no eliminations from or additions to the list were necessary. The Committee, therefore, unanimously voted to reaffirm Simplified Practice Recommendation R1–32 Vitrified Paving Brick, without change, for another year.

George A. Cooper, of the Division of Simplified Practice, then invited the attention of the Committee to the desirability of identifying the simplified sizes of brick in trade literature, on invoice forms, in magazine articles, and advertising. He submitted a number of samples showing how other industries had applied the principle of identification to their respective products.

On motion by Mr. Renkert, the Committee recommended to the National Paving Brick Association that it call the attention of its members to the desirability of identification in the production and sale of paving brick. The coöperation of the Division of Simplified Practice was offered in supplying the necessary information to brick manufacturers and representative users.

On motion by Prof. Lawson, the Committee extended its appreciation and thanks to Messrs. Schlesinger and Campbell for their work in connection with the 1932 survey, and expressed their high approval of the thorough and comprehensive results.

Mr. Schlesinger informed the members of the Committee that Prof. Lawson had recently been honored with the nomination for president of the American Society for Testing Materials.

Colonel Compton called attention to the fact that the President of the United States had nominated Lyman J. Briggs to be Director of the Bureau of Standards.

The Committee then proceeded to the election of its officers for the ensuing year. As a result of the unanimous vote, Col. Compton was elected Chairman, Prof. Lawson, Vice-Chairman, and A. B. Galt, Secretary.

There being no further business, the committee adjourned at 12:05 P.M., subject to call of the chairman.

NOTE: As a result of the action of the committee at its 1933 meeting, the recognized varieties and sizes of paving brick are as follows:

VARIETIES

Sizes in Inches[a]

Plain wire-cut brick (vertical fiber lugless) as usually laid			Wire-cut lug brick (Dunn)		
Depth	Width	Length	Depth	Width	Length
2½	4	8½	3	3½	8½
3	4	8½	4	3½	8½
Repressed lug brick			**Vertical fiber lug brick**		
Depth	Width	Length	Depth	Width	Length
4	3½	8½	3	4	8½

[a] Tolerance of ⅛ inch depth and width and of ¼ inch in length allowable.

THE CERAMICS EXPOSITION AT RUTGERS UNIVERSITY

The third Ceramics Exposition, Ceramics Building, Rutgers University, broke all previous records for diversification of exhibits and number of visitors in attendance.

FIG. 1.—Demonstration of Rutgers frictile machine used in testing the frictional qualities of nonslip tile. (Tile Manufacturers' Fellowship.)

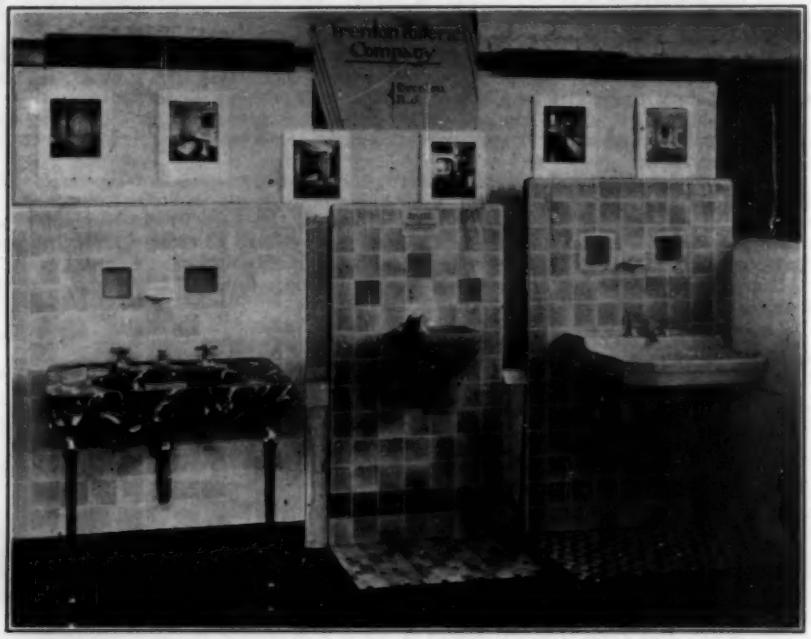

FIG. 2.—Group of pieces in sanitary ware division.

FIG. 3.—View of main exhibit room, showing art pottery and glassware exhibits.

FIG. 4.—Section of tile exhibits. (Tile Manufacturers' Fellowship.)

Eight thousand people from many points in New Jersey and adjacent states registered at the Exposition from its opening on May 5 to the close on May 15.

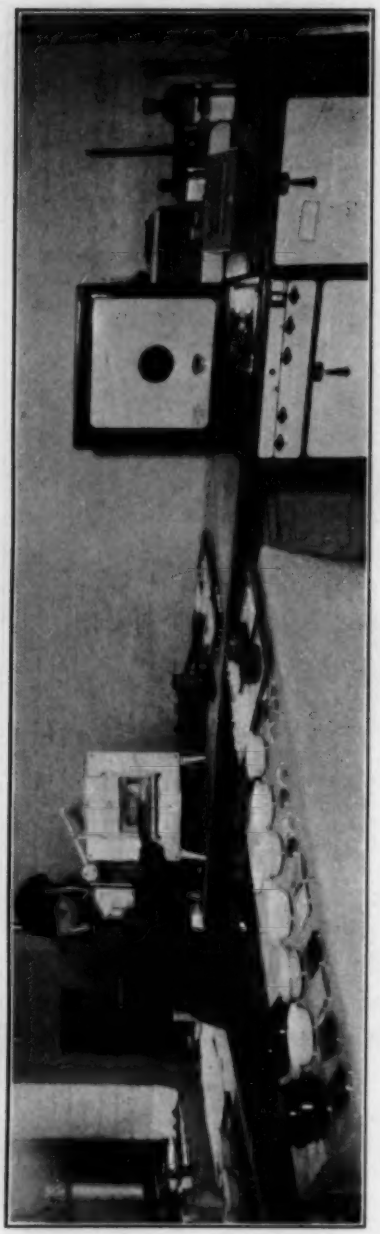

FIG. 5.—Demonstration of enameling, and section of enamel exhibit.

With practically every manufacturer in the State (and several out of state firms) participating, the Ceramics Building was transformed into a huge showroom for displaying the choicest products of the ceramic industries, raw materials, and pioneer pottery of New Jersey.

Visitors suggested names for a new design in china by Lenox, Incorporated, in honor of the Ceramics Exposition. Visitors also guessed the weight of a block of clay from Edgar Bros. Company.

A potter engaged on an old-type wheel and a corps of decorators from the Scammell China Company especially attracted the visitors. The latter demonstration included the preparation and application of the new "Rutgers" design to tableware of various kinds.

The apparatus used in testing the qualities of floor and wall tile for the various conditions of service to which they are subjected was on display. An exhibit showing the production of faience tile, by the Mueller Mosaic Company, from the raw materials to the finished glazed product, was highly interesting and educational.

A glassblower was surrounded by a group of fascinated watchers from start to close. He fashioned numerous ships, animals, pens, and other novelties, which were distributed to the visitors.

The new kilns recently installed at the Ceramics Building were in operation during the Exposition. Demonstrations of enameling processes were given by students and their instructors; attractive enameled pans with monograms, made in the enamel laboratory, were given to the visitors.

Through the coöperation of the New Jersey State Museum, the Department was able to secure the collection of early New Jersey pottery recently featured by that institution. Statuary from the firm of Ott and Brewer, modeled by Broome and featured at the Centennial Exposition in 1876, was included in this group. Specimens of the first Belleek china produced in the Trenton district by Willetts, Lenox, and others, were also on display. An exhibit of the pioneer potters of New Jersey, including representative pieces from the South Amboy, Perth Amboy, Trenton, Elizabethtown, and New Brunswick districts, was exhibited by John M. Connor, Jr., of Metuchen, N. J. Rare pieces from the collection of Charles A. Philhower of Westfield, N. J., provided an interesting contrast with the latest products of the potteries now in operation in the State, includ-

FIG. 6.—Section of raw materials exhibit.

ing Lenox, Inc., Fulper Pottery Company, Vitric China Company, and numerous schools and individual craftsmen. Pleasing colors and forms distinguished these latter exhibits, many of which showed the present modernistic trend.

FIG. 7.—Demonstration of china decorating by group of workers from Scammell China Company, Trenton, N. J.

An exhibit of art pottery in various new glaze effects was presented by the students in the Department of Ceramics at Rutgers.

Special features were arranged at the Exposition in connection with the State Teachers' Conference, Ceramic Association of New Jersey Day (which included a lecture

FIG. 8.—Section of electrical porcelain and stoneware division.

on Indian Pottery by Charles A. Philhower), Prep School Weekend, and Parents' Day.

This Exposition has shown a marked increase in the number of exhibitors (84) and attendance over the two previous affairs of this kind in 1929 and 1931, respectively. A survey indicates that eight states, 130 New Jersey towns, and 22 towns not in New Jersey were represented and a total of 8000 persons registered at the Exposition.

BUYERS' GUIDE

A

Abrasives (Alundum-Crystolon)
Norton Co.

Alozite (Refractory Products)
Carborundum Co.

Alumina (Hydrate and Calcined)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Pennsylvania Salt Mfg. Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Aluminum Oxide (Fused)
The Exolon Co.
The Vitro Mfg. Co.

Alundum (Refractory Products)
Norton Co.

Ammonium Bifluoride
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Ammonium Carbonate
Ceramic Color & Chemical Mfg. Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Antimony Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

B

Ball Mills
McDanel Refractory Porcelain Co.

Ball Mills (Laboratory Type)
Ceramic Color & Chemical Mfg. Co.

Barium Carbonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Roessler & Hasslacher Chemical Co
The Vitro Mfg. Co.

Batts
Carborundum Co. (*"Carbofrax Alozite"*)
Norton Co. (*Alundum Crystolon*)

Bitstone
Potters Supply Co.

Blocks (Refractory)
Carborundum Co.
Norton Co.

Borax
American Potash & Chemical Co.
Drakenfeld & Co., B. F.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Borax Glass
Pacific Coast Borax Co.

Boric Acid (Anhydrous)
Pacific Coast Borax Co.
The Vitro Mfg. Co.

Boric Acid (Crystal, Granular, or Powder)
American Potash & Chemical Co.
Drakenfeld & Co., B. F.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Bricks (Refractory)
Carborundum Co. (*"Carbofrax Alozite"*)
Norton Co.

C

Carbofrax (Refractory Products)
Carborundum Co.

Carbolon (Refractory Products)
The Exolon Co.

Carbonates (Barium, Lead)
Ceramic Color & Chemical Mfg. Co.
The Roessler & Hasslacher Chemical Co
The Vitro Mfg. Co.

Caustic Soda
Ceramic Color & Chemical Mfg. Co.
Pennsylvania Salt Mfg. Co
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Cements
Carborundum Co.

Ceramic Chemicals
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Chromium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay (Ball)
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Potters Supply Co.
The Roessler & Hasslacher Chemical Co.
Spinks Clay Co. H. C.
The Vitro Mfg. Co.

Clay (China)
Ceramic Color & Chemical Mfg. Co
Drakenfeld & Co., B. F.
Edgar Brothers Co.
Hammill & Gillespie, Inc.
Paper Makers Importing Co.
The Vitro Mfg. Co.

Clay (Electrical, Porcelain)
Ceramic Color & Chemical Mfg. Co.
Edgar Brothers Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Spinks Clay Co., H. C.
The Vitro Mfg. Co.

Clay (Enamel)
Ceramic Color & Chemical Mfg. Co.
Edgar Brothers Co.
Kentucky-Tennessee Clay Co.
Metal & Thermit Corp.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay (Fire)
Edgar Brothers Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Potters Supply Co.

BUYERS' GUIDE (continued)

Clay (German Vallendar)
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The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay Miners
Edgar Brothers Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clay (Potters)
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clay (Sagger)
Edgar Brothers Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Potters Supply Co.
Spinks Clay Co., H. C.

Clay (Wad)
Kentucky-Tennessee Clay Co.
Potters Supply Co.
Spinks Clay Co., H. C.

Clay (Wall Tile)
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clocks (Gauge Board)
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Cobalt Oxide
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Drakenfeld & Co., B. F.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Colors
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Cornwall Stone
Hammill & Gillespie, Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Cornwall Stone (Imported)
The Roessler & Hasslacher Chemical Co.

Crucibles (Filter, Melting, Ignition)
Norton Co.
Potters Supply Co.

Crystolon (Refractory Products)
Norton Co.

D

Decorating Supplies
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Drakenfeld & Co., B. F.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Drying Machinery
Ferro Enamel Corp.

E

Electrical Porcelain
Paper Makers Importing Co.

Enameling Equipment (Complete)
Chicago Vitreous Enamel Products Co.
Ferro Enamel Corp.
Porcelain Enamel & Mfg. Co.

Enameling Furnaces
Carborundum Co. (*Carboradiant*)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Norton Co.
Porcelain Enamel & Mfg. Co.

Enameling Iron (Sheet)
American Rolling Mill Co.

Enameling Muffles
Carborundum Co. (*Carbofrax*)
Norton Co. (*Alundum*)

Enameling (Practical Service)
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Ferro Enamel Corp.
Porcelain Enamel & Mfg. Co.
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The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

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Equipment (Porcelain Enameling)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Porcelain Enamel & Mfg. Co.

Exolon (Refractory Products)
The Exolon Co.

F

Feldspar
Ceramic Color & Chemical Mfg. Co.
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Flint
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Flint Pebbles
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Floors (Non-Slip)
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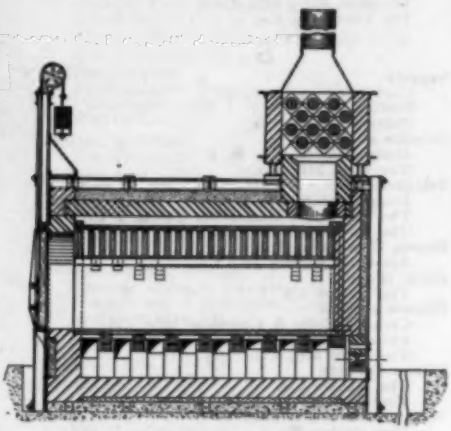

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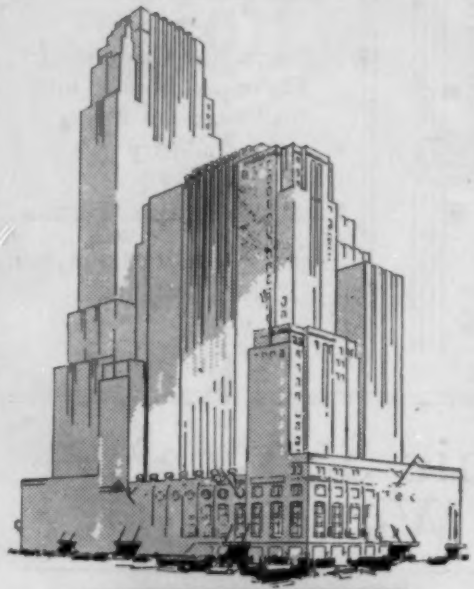

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